CHEMICAL ENGINEERING

November 27, 1961

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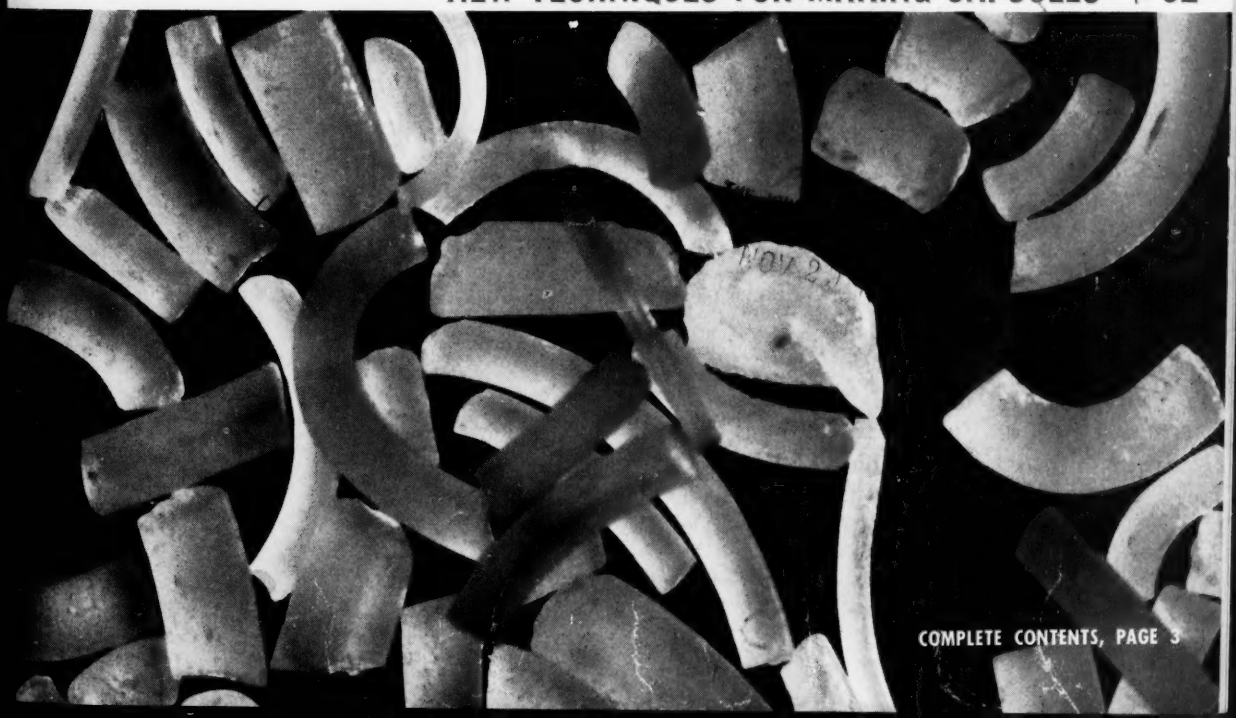
NEW TECHNIQUES FOR MAKING CAPSULES p. 52



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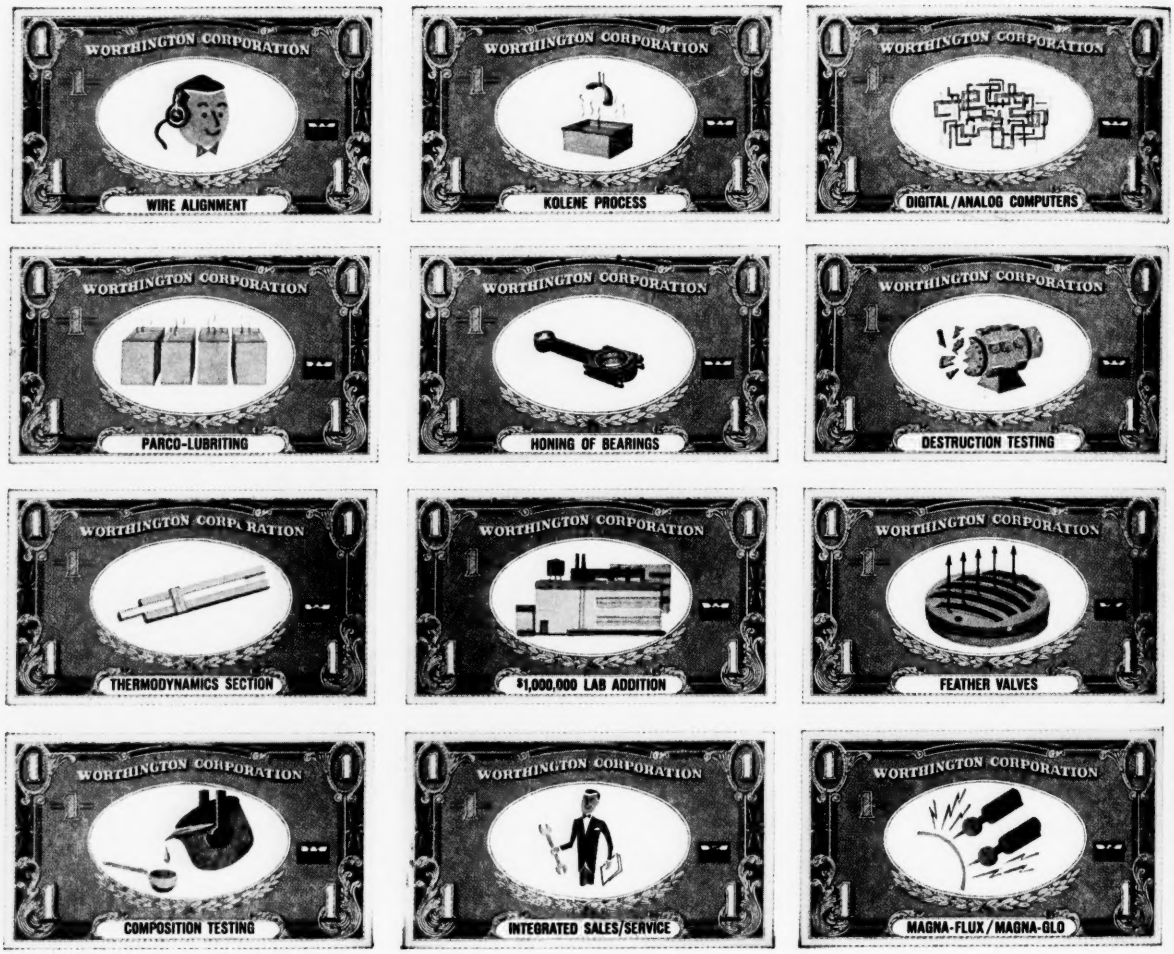

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These are dollars that are paid out every day for Worthington compressors. They reveal a few of the extra or "hidden values" that make the compressors worth most for the dollars invested. But even more important, they give a clue about real compressor values.

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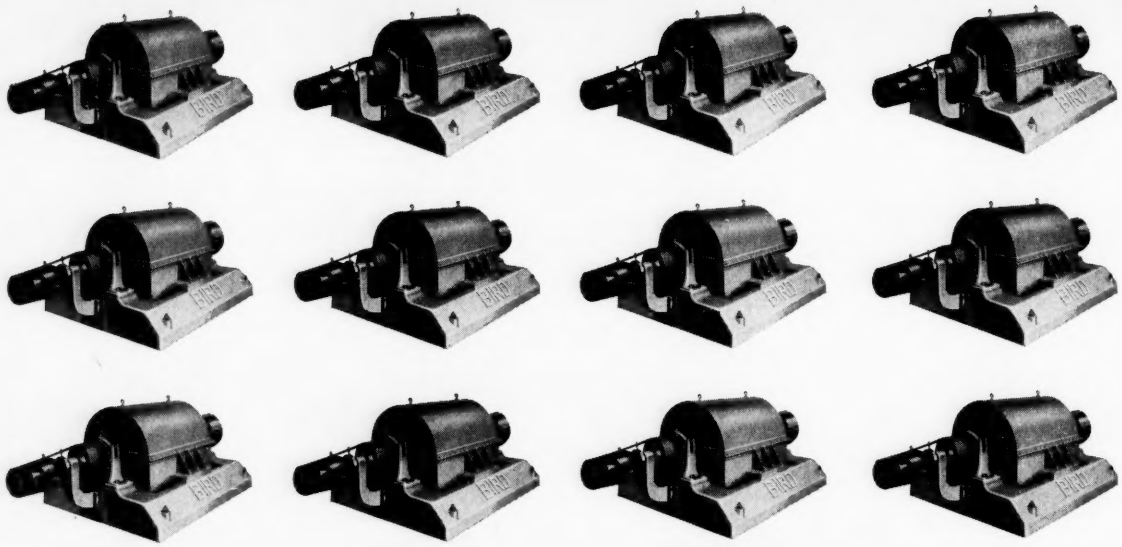

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CHEMICAL ENGINEERING

November 27, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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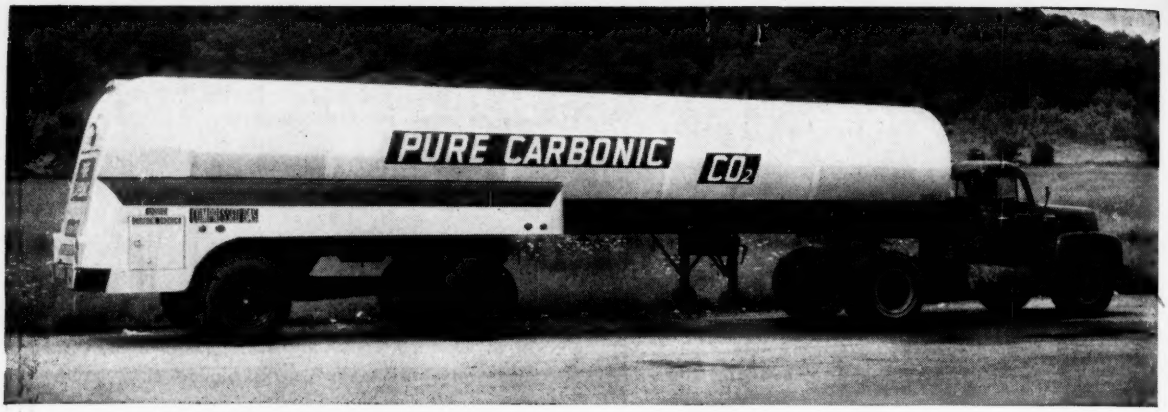

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highlights of this issue

CUT OVERDESIGN, BOOST PROFITABILITY

"Many designers," writes Charles Carroll of Dow Chemical, "seem to forget that the principal purpose of building a plant is to enable a product to be manufactured and sold at a profit, rather than creating a structure that the designer can point to with pride." But what incentive is there for the project engineer to gamble on design innovations that could reduce costs? And what production manager in his right mind would approve such risk-taking in a plant he was going to operate? In this provocative article (p. 113), Mr. Carroll analyzes the factors that encourage overdesign, and recommends organizational procedures for obtaining operable plants at minimum cost.

NEW TECHNIQUES FOR MAKING CAPSULES

Maybe it doesn't rate as a full-fledged chemical engineering unit operation, but encapsulation is getting a lot of attention today. Latest news is from National Research Corp., about its vacuum process for encapsulating solids (p. 52). This process will be developed further, under Air Force contract, for encapsulation of ingredients for solid propellants.

SOME MYTHS OF PROFESSIONAL PRACTICE

Why are so many engineers dissatisfied with their jobs? Why do they envy the professional stature of physicians and lawyers? Why do they aspire to management positions? Psychologist S. M. Bernd explores some of the factors that motivate engineers in this You & Your Job feature (p. 126). He blames "fuzzy-minded thinking" for most of the engineer's concern about "professionalism."

YOU CALL THE TURN

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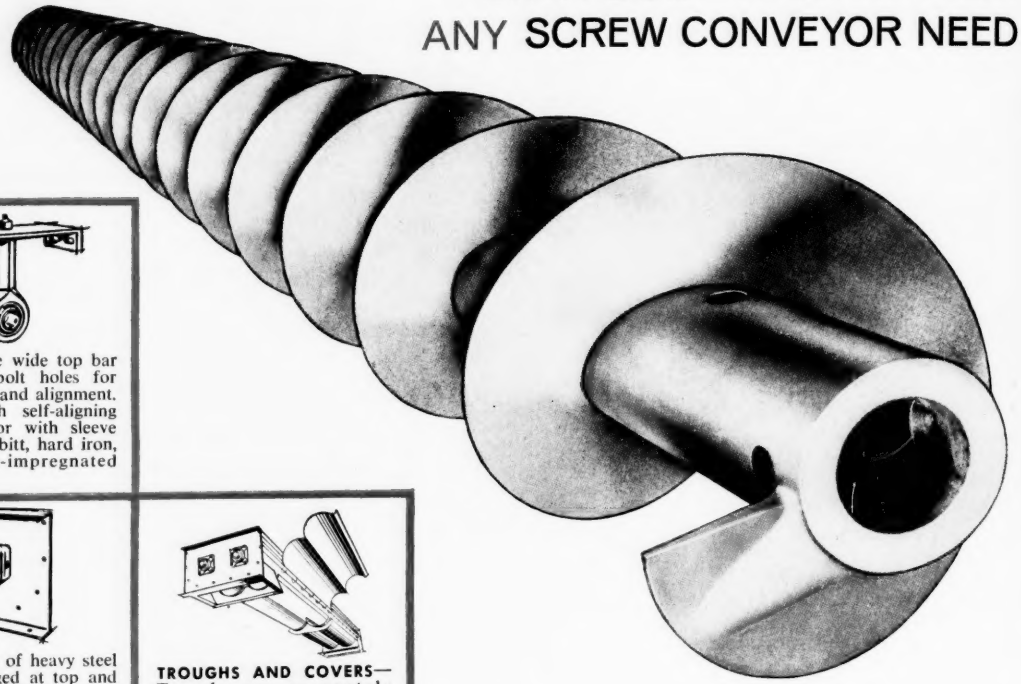
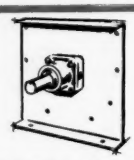


HANGERS have wide top bar with slotted bolt holes for easy assembly and alignment. Available with self-aligning ball bearing or with sleeve bearing in babbitt, hard iron, bronze or oil-impregnated wood.



TROUGH ENDS of heavy steel plate are flanged at top and bottom. Furnished with babbitted, bronze or single or double ball bearing flange block with or without trough end seal. Blocks are interchangeable.

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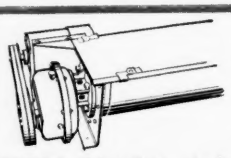
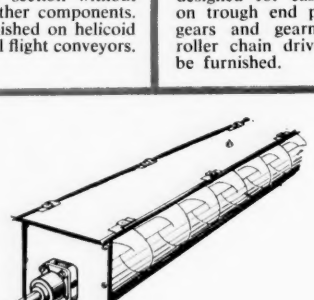


DRIVES—Link-Belt shaft-mounted speed reducers are simple, compact, rugged — designed for easy mounting on trough end plate. Moto-gears and gearmotors with roller chain drives can also be furnished.



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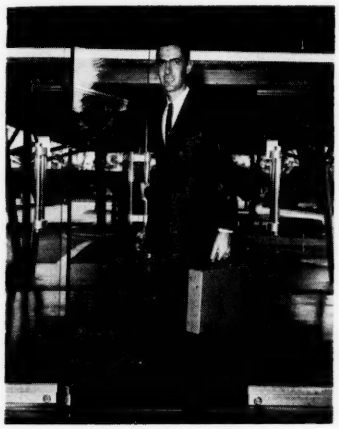
CE's new Southwest Editor reports for duty



Passing through the portals of the Prudential Bldg., which houses our office in Houston, is Peter J. Brennan, newly appointed Southwest Editor for CHEMICAL ENGINEERING.

He fills the vacancy created when Tom Arnold resigned in September to enter law school at Yale.

Pete is no stranger to CE readers. He was on our New York editorial staff for nearly two years as our Operation & Maintenance editor. He rejoins CE after spending most of this year with General Dynamics in San Diego. A chemical engineering graduate of Catholic University, he has chalked up industry service with Union Bag, Standard Brands, Stauffer Chemical and Westinghouse.

Whereas Pete's predecessors (Tom Arnold, and Jim Lee before him) divided their time between CE and our sister McGraw-Hill publication, Chemical Week, *Pete will now be working full time for CE. This move recognizes the growing importance of the chemical engineer in the Southwest.*

Con: "Petrochemical"

Sir:

In your Sept. 4 issue (p. 7) you ask, "What Do You Mean, 'Petrochemical'?"

This is a good question. I began to wake up to the utter worthlessness of this word several years ago when I was setting up my personal files covering the petroleum industry. In working with the petrochemical section, it suddenly dawned on me that I was making the chemical industry a subhead of the petroleum industry. Recognizing the nonsense of it all, I transferred the whole file to "chemical manufacturing" where it properly belonged.

There is absolutely no need for the word "petrochemical." Other industries, such as the food industry, steel industry and paper industry, manufacture chemicals as a sideline. But none has seen fit to tag its chemicals with a name indicating their origin. Why, then, is there any need for one in the petroleum industry?

You hit the nail on the head when you said, "In essence, the only distinctive characteristic of a petrochemical is its ancestry, and in the melting pot of modern chemical technology, family connections quickly fade away." The way to get rid of the confusion caused by this word "petrochemical" is to get rid of the word. There is no other way.

DAN A. H. OLSON
Redondo Beach, Calif.

Pro: African Alumina Plant

Sir:

We note with interest the comprehensive article in your Oct. 2 issue (pp. 42-4), "African Alumina Plant Reshapes Bayer Process." Further details on some of our equipment installed in this plant are worthy of mention.

The mud settlers and washers that we furnished constitute, to the best of our knowledge, the largest thickener installation in the world. These 26 100-ft.-dia. thickeners all have flat bottoms and peripheral discharges, the first large red-mud thickener installation in the world with this feature. They also have 3-ft. platform lifting devices, originally designed for this job and now accepted throughout the aluminum and other industries.

Other Eimco thickeners are used for white-mud settling. These two 60-ft.-dia., four-compartment tray thickeners rake out the bottom compartment and have a platform lift.

Much of the filtration equipment that we furnished is also novel, such as the five seed filters mentioned in your story. Each of these disk filters is 12 ft., 6 in. dia., with 12 disks per filter. Each is of the special Hy-Flow design, developed specifically for this service. Final filtration after second-stage causticization of the white mud is handled on our three 11-ft., 6-in.-dia. by 12-ft. drum filters. The two stages of hydrate filtration are also done on four Eimco 11-ft., 6-in. by 12-ft. drum filters, specially designed for this washing and filtration step.

Incidentally, Holly Sugar Corp.'s new beet sugar system, also described in your Oct. 2 issue (Process Flowsheet, pp. 76-8), is built around the EimcoBelt continuous-belt vacuum filter.

ALFRED F. MANSBACH
Eimco Corp.
Salt Lake City, Utah

Con: Common Thermo Errors

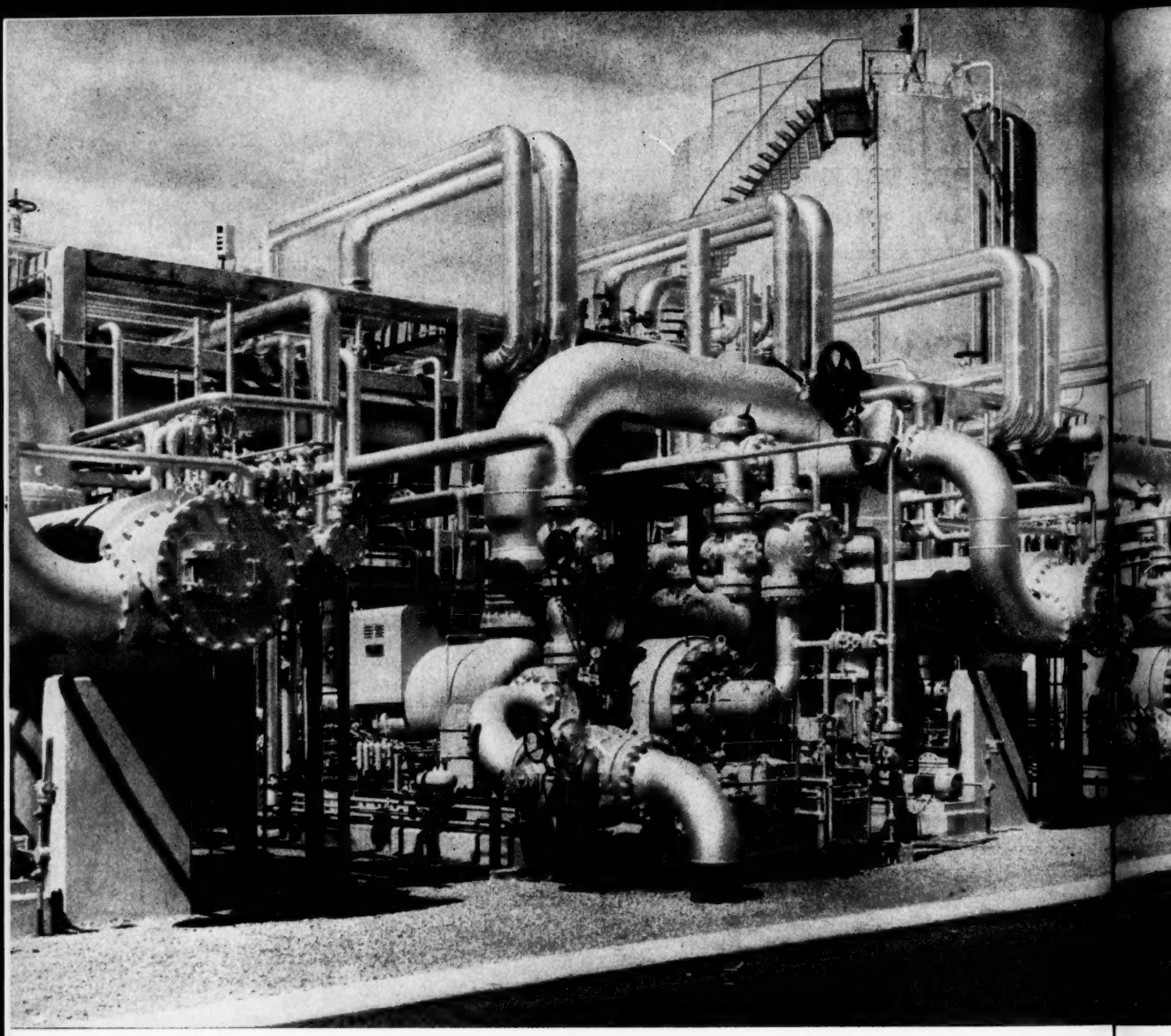
Sir:

I am very disturbed by Dr. Cannon's article, "Some Common Errors in Thermodynamics" (Aug. 7, pp. 127-8). While I agree that a good deal of confusion exists in thermodynamics, the author has not enlightened the reader with his interpretations. In fact, he has further confused the issue.

I believe that the "common errors" discussed by Dr. Cannon can be avoided by the following definitions:

System—That part of the universe isolated for study.

Surroundings—That part of the universe immediately outside the system. *(Continued on page 170)*

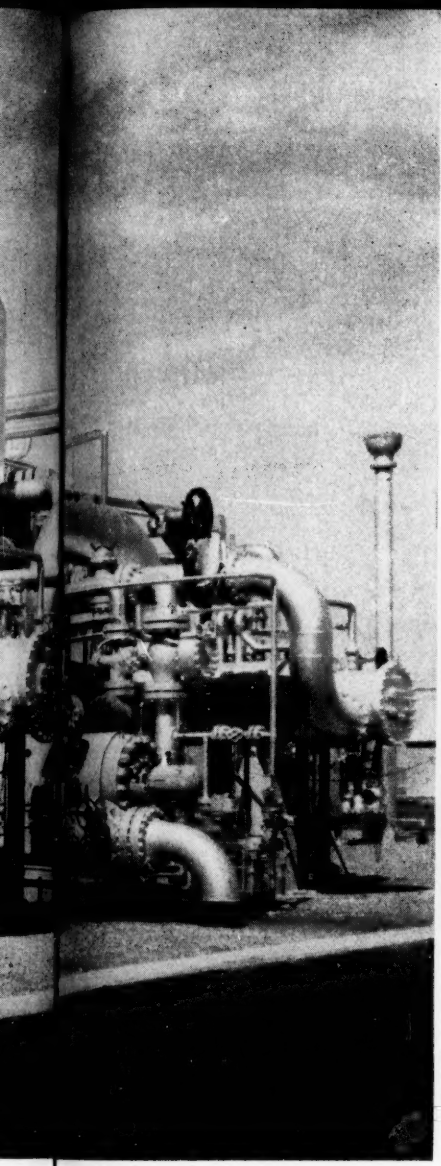


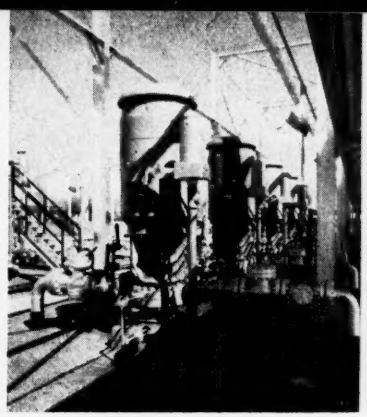
AT HUMBLE'S KING RANCH GAS LA

These pumps have a combined capacity of 139,000 gpm—a to

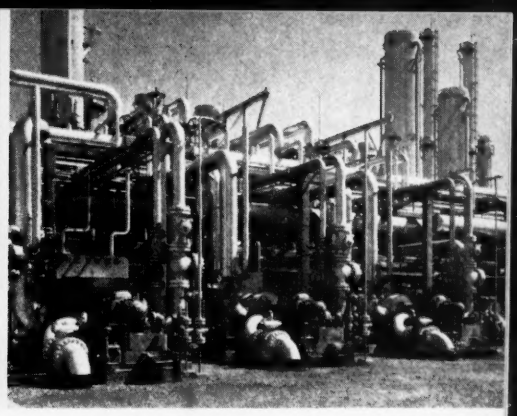
This new plant also contains five Ingersoll-Rand air compressors and two Ingersoll-Rand steam-jet ejectors for vacuum service.

Whatever *you* need in the process-pump line is available from Ingersoll-Rand, manufacturer of the world's *most complete line* of centrifugal pumps.

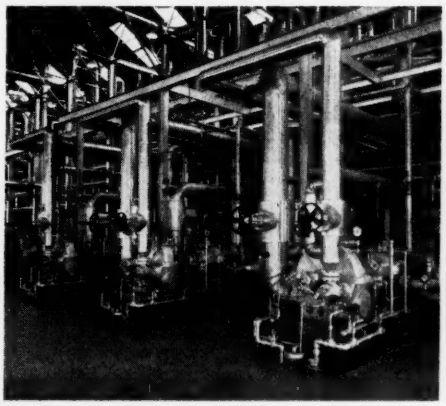




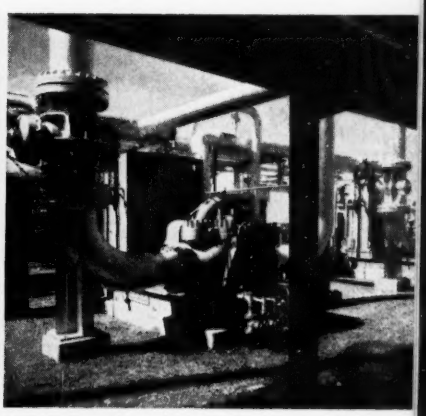
Five Ingersoll-Rand VHTB multi-stage vertical pumps for handling propane and butane at shipping terminal for distribution to product pipelines.



Three Ingersoll-Rand HMTA four-stage pumps specially designed with one interstage bleed-off connection to combine two lean absorption oil services for pressure levels of 480 and 1000 psig.



Three of four Ingersoll-Rand CNTA eight-stage boiler-feed pumps operating at a discharge pressure of 750 psig.



Two Ingersoll-Rand BHV hydraulic turbines designed to recover power from the high and low pressure rich oil stream to drive a 1500 hp and 1000 hp induction generator.

Two of three Ingersoll-Rand CHTA six-stage, barrel-type pumps specially designed with two interstage bleed-off connections. Three lean absorption oil services are combined in one pump for pressure levels of 1000, 1270 and 1880 psig.

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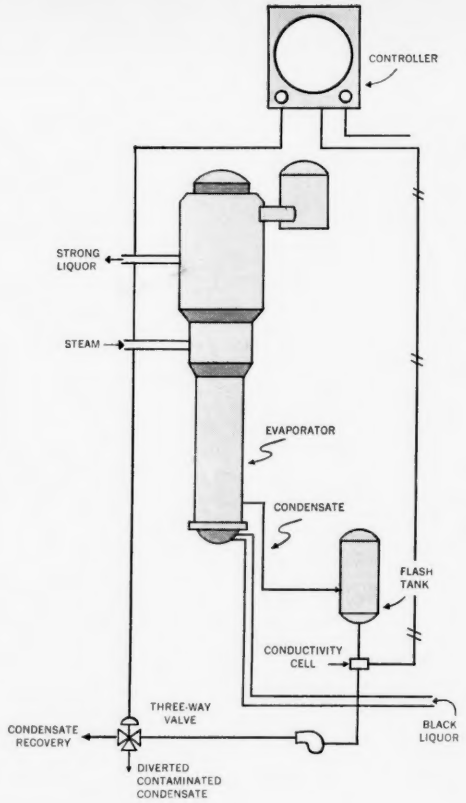
The Honeywell Three-Way Diverting Valve shown on the opposite page safeguards plant equipment at St. Regis Paper Company in Tacoma, Washington. Located in the steam condensate line leading from the multi-effect black liquor evaporator, the valve protects vital boiler tubes and pipes by diverting contaminated condensate. Contamination resulting from the presence of black liquor in the condensate is detected by a conductivity cell. When the concentration passes safe limits, a Honeywell *ElectroniK 15* Controller signals the valve to divert the contaminated condensate.



Protect plant equipment and reduce down-time with...

HONEYWELL THREE-WAY DIVERTING VALVES

Honeywell Three-Way Diverting Valves help protect vital plant equipment by diverting contaminated fluids to bypass, discharge or recirculating lines.

A Honeywell valve control system—consisting of a detecting element, a controller and a diverting valve—can provide simple, automatic protection for your plant equipment. A small investment in a Honeywell system of this type will help you keep your process equipment in top operating condition . . . materially reducing maintenance and down-time.

Other Honeywell valve control systems to keep temperature, pressure, level, pH and other process variables under strict control are also available.

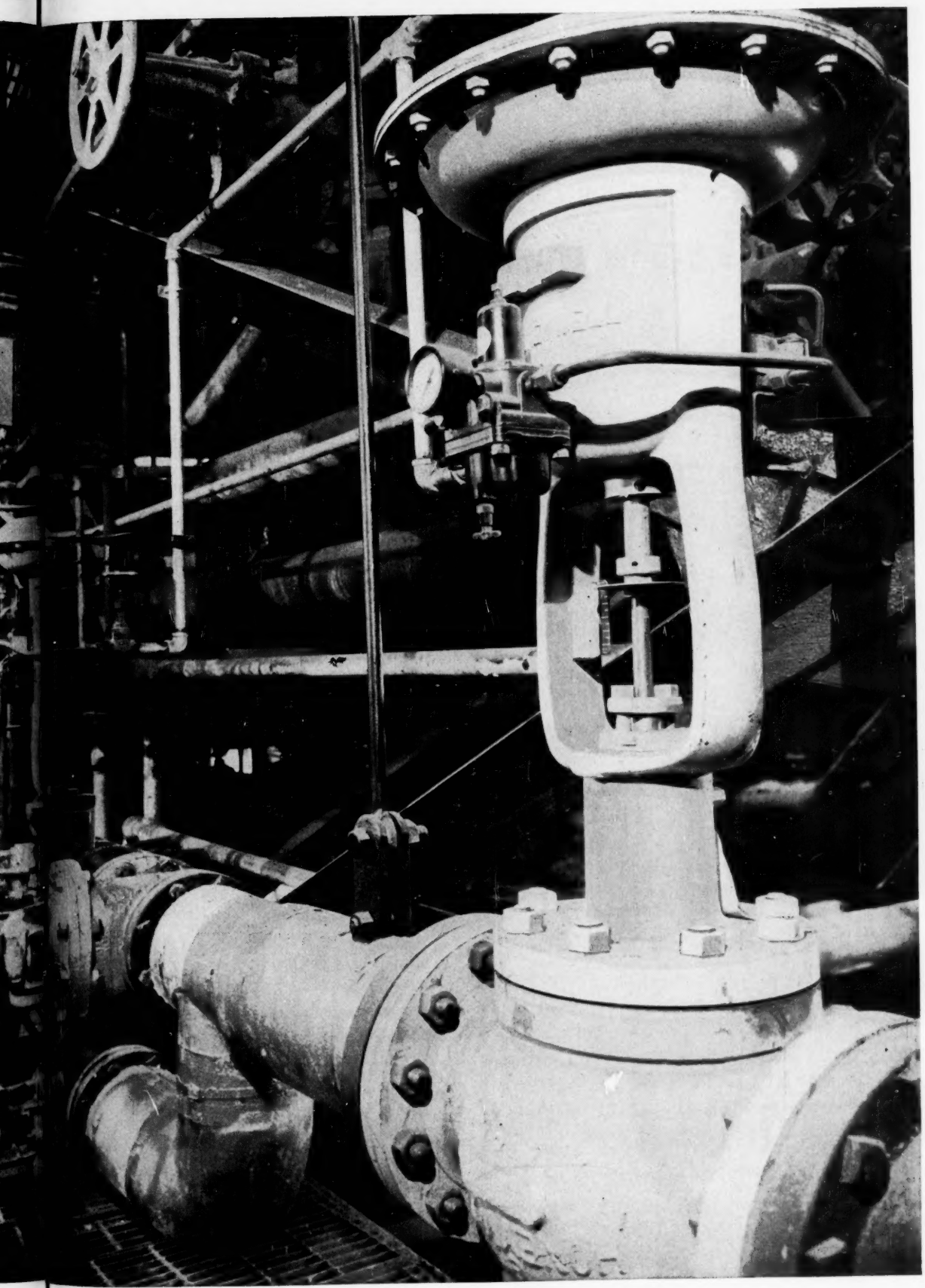
The dependable performance and continuous protection afforded by these valves are the result of Honeywell's proven design, careful workmanship and broad process control know-how. *Every* aspect of valve performance is considered in relation to the overall control system. It is this "whole picture" approach that sets Honeywell control valves apart, and rewards you with reduced maintenance and more reliable operation.

Write today for information on "Three-Way Valves" and their application.
MINNEAPOLIS-HONEYWELL, Fort Washington, Pennsylvania.

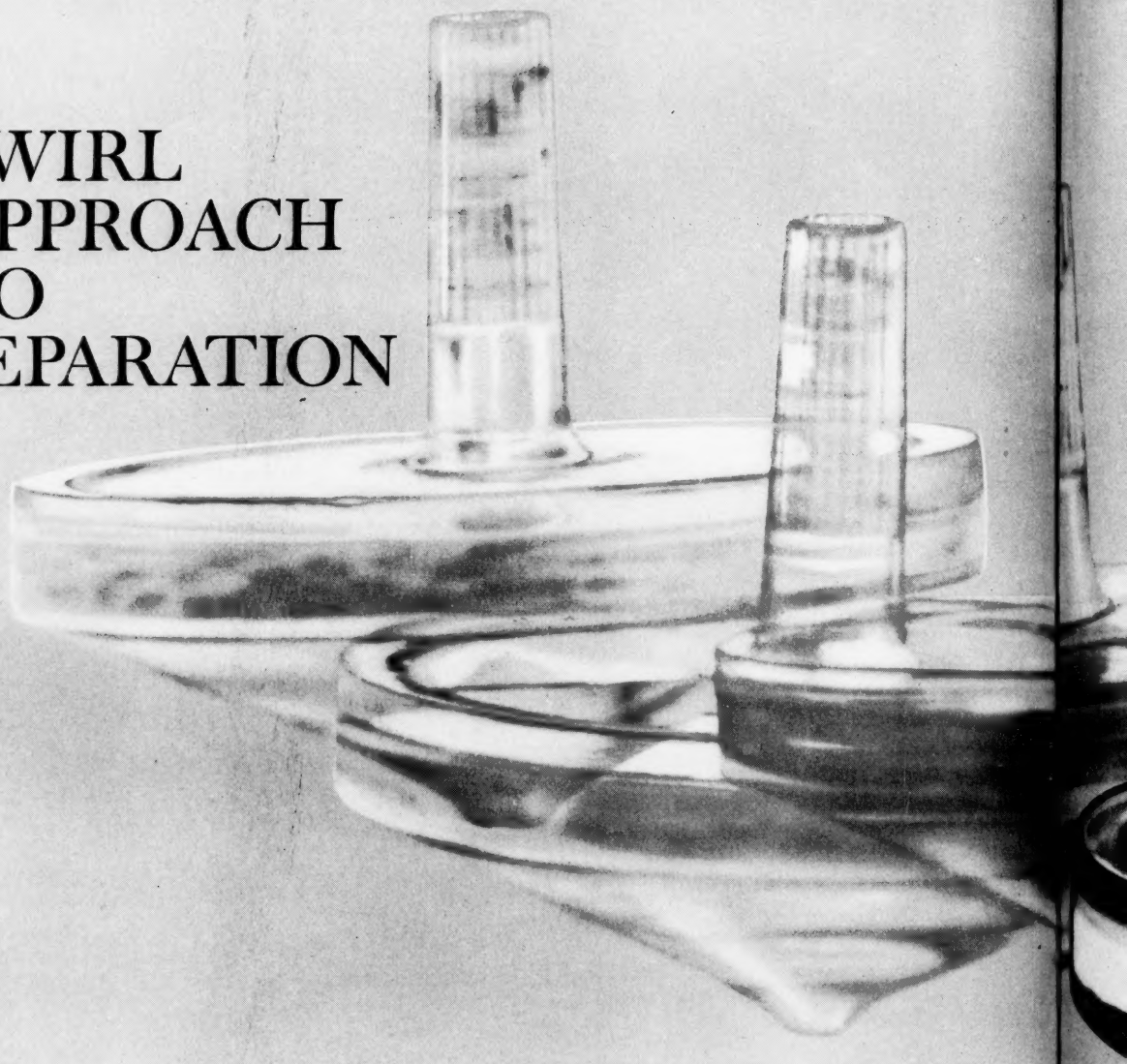
Honeywell

First in Control

HONEYWELL INTERNATIONAL Sales and Service offices in principal cities of the world.
Manufacturing in United States, United Kingdom Canada, Netherlands, Germany, France, Japan.

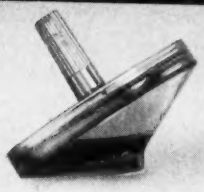


SWIRL APPROACH TO SEPARATION



Of all the separating techniques available to the process designer, few have the basic simplicity, range of application, and handling capabilities of the centrifuge. Only the centrifuge in its many forms, can separate materials ranging from immiscible liquids to crystalline solids, from fibrous pulp to process liquids and slurries . . . can handle particles as fine as 1 micron in diameter, or liquids differing only a fraction in specific gravity . . . can deliver separating power up to 13,200 times the force of gravity . . . can handle capacities up to 18,000 gallons or 70 tons per hour, at temperatures to 450° F and pressures ranging from 5 mm Hg to 150 psi.

Sharples centrifuges and centrifugal systems are performing these tasks every day in thousands of plants throughout the world. Sharples' experience and know-how in the application of centrifugal separation is ready to go to work for you—in designing and manufacturing complete centrifugal process systems, or in aiding you in the selection of single-unit centrifuges from Sharples' complete line. The Sharples Corporation, 2300 Westmoreland St., Phila. 40, Pa.



This hollow top—containing small plastic beads, water and oil—graphically illustrates the basic simplicity of the centrifuge. By twirling the top at high speed, it is possible to separate the contents into three, sharply divided concentric rings.

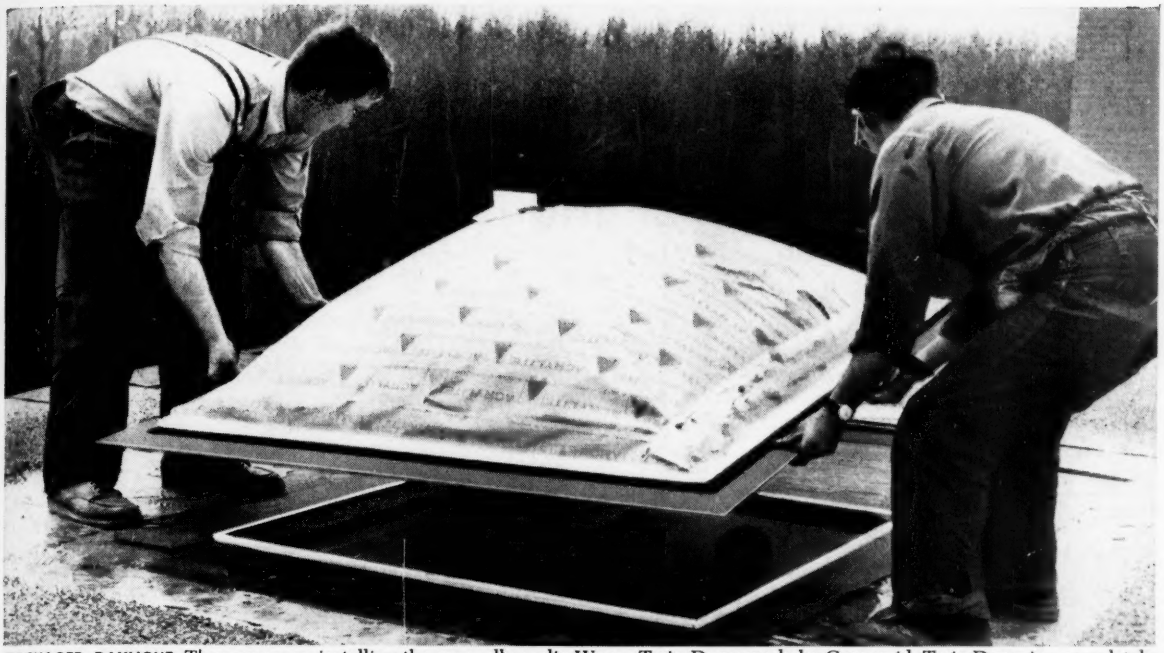
SHARPLES

Representatives and associated companies throughout the world

CYANAMID

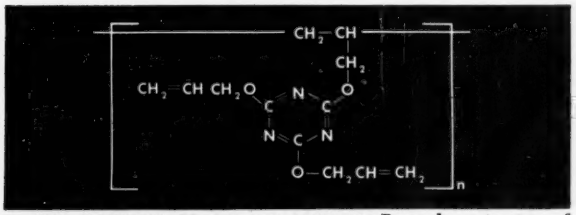
Chemical Newsfront

EASIER TO SEE, EASIER TO SELL! From beer to bandages, packaging treated with CALCOFLUOR® WHITE brightener stands out on shelf or counter, boosts impulse sales. This remarkable product absorbs invisible UV-rays from fluorescent lighting, re-emits it as additional eye-catching brilliance. Grocery bag above is fortified with Cyanamid's Melostrength® resin. Use coupon for added information. **(Dyes Department)**



PACKAGED DAYLIGHT. These men are installing the new, all-acrylic Wasco Twin Dome made by Cyanamid. Twin Dome is a completely sealed, insulated, shatterproof, low-profile skylight with inner and outer domes available in any combination—clear, colorless, white translucent or reflective—to allow maximum control of light levels and heat gain. The domes are bonded to an aluminum nailing flange for easy installation and have an inch of "dead air" between them for exceptionally efficient insulation against heat and cold.
(Wasco Products Department)

VINYL CONVERTIBLE WINDOWS stay transparent and flexible when the formulation includes CYASORB® UV light absorbers. Cyasorb causes vinyl windows to resist discoloration and cracking under the sun's damaging ultra-violet rays. It also retards the yellowing of the inner plastic layers in safety glass. Secondary benefits here may be better vision and the protection of the decorative color in the car's upholstery. **(Intermediates Department)**



A NEW APPROACH TO AN OLD PROBLEM. Pre-polymerization of *triallyl cyanurate* (TAC) should provide more effective use of this polyfunctional monomer through concentration of reactivity in large molecules and decrease of volatility.

Our data on preparation of TAC pre-polymers and pre-copolymers with vinyl monomers should be helpful in research directed toward upgrading vinyl systems by increasing heat resistance and decreasing flow, creep and tendency to stain. Write for technical literature.
(Market Development Department)

For further information on products in this advertisement wire, or mail this coupon to: CE-111

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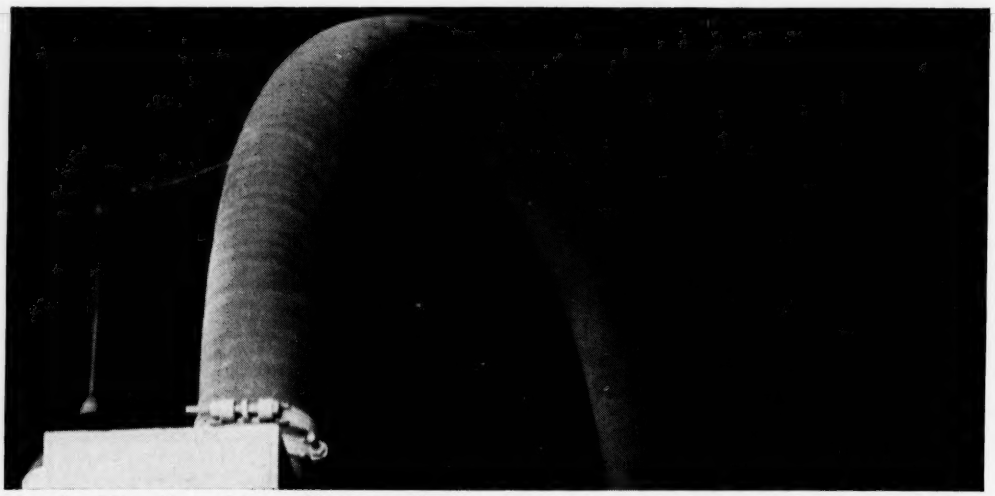
US RUBBER

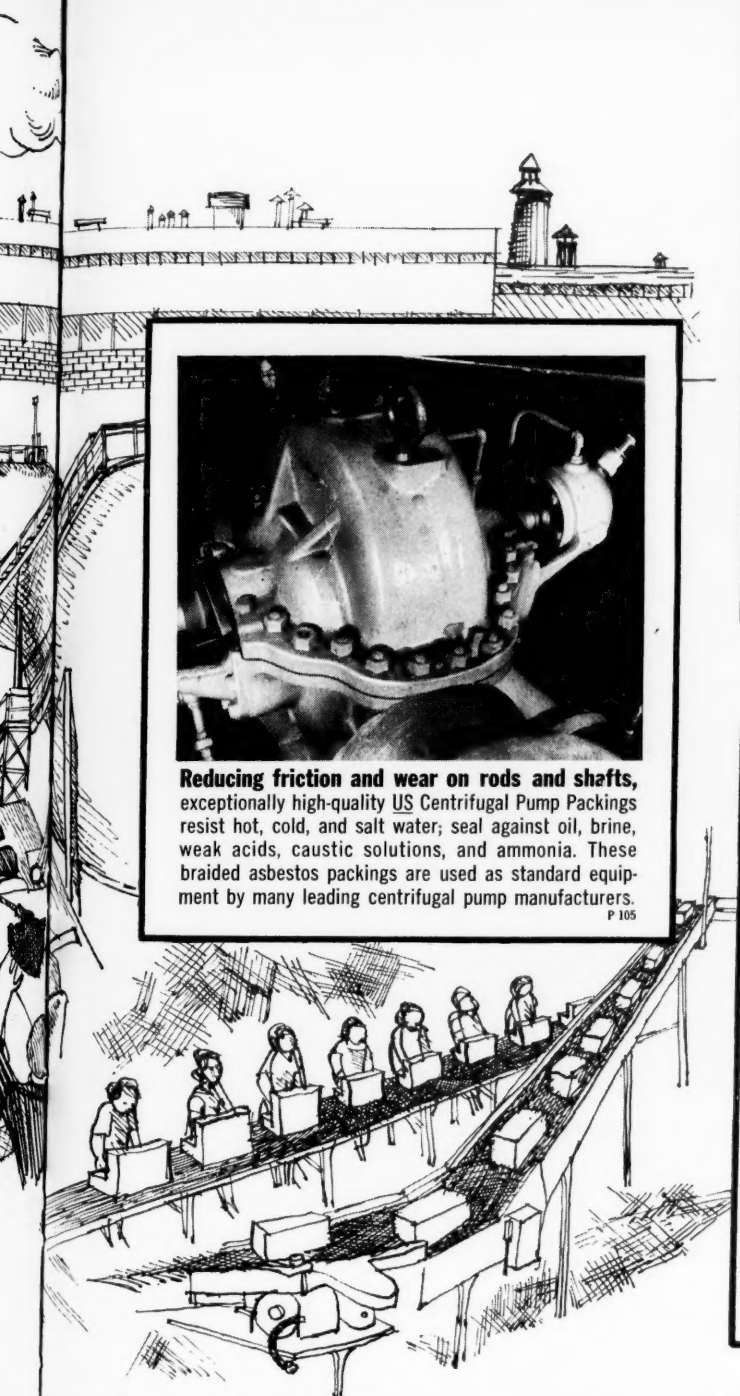
AT THE HEART OF INDUSTRY...



Carrying 200 gallons of ferro silicon per minute is all in a day's work for limber, abrasion-resistant U.S. Pilot® Pipe in a large iron ore producer's heavy media department. Company records show U.S. Pilot Pipe lasts about 12 times longer than metal pipe, requires no maintenance, saves room by eliminating the need for elbows.

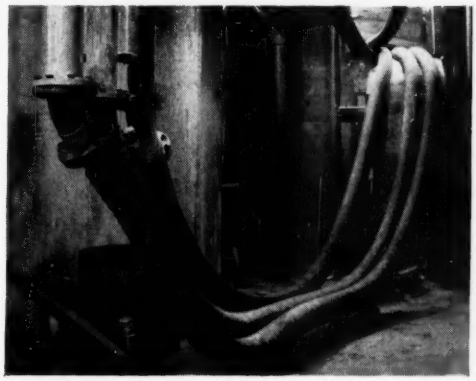
H 113

Name the job in the chemical industry, and you'll find US there. For whatever the job—large or small, complex or simple—it gets done more efficiently, with less maintenance, and at more profit, with the help of US Industrial Rubber Products. Reason? US knows and meets the industry's requirements.



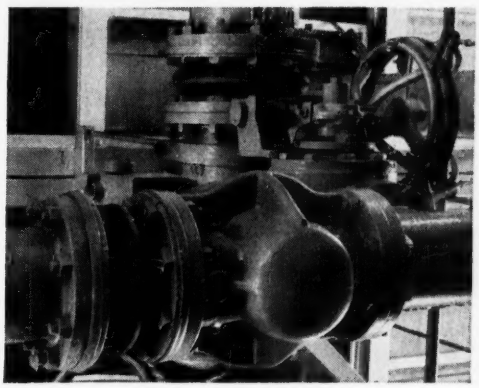
Reducing friction and wear on rods and shafts, exceptionally high-quality US Centrifugal Pump Packings resist hot, cold, and salt water; seal against oil, brine, weak acids, caustic solutions, and ammonia. These braided asbestos packings are used as standard equipment by many leading centrifugal pump manufacturers.

P 105



Softening water on a chemical diet, U. S. Giant® Acid Hose is unharmed by hot lime, ferric sulphate, alum solution, and soda ash at Kansas City Water Works' chemical treatment plant. An economical way of conveying softening chemicals to the water supply, U. S. Giant is used for suction and discharge, is extremely flexible, resists abrasion, impact, and weather.

H 114



Designed to meet today's most rigid requirements, U. S. AMR Expansion Joints handle flow surges, high pressures, and high temperatures unheard of a few years ago. AMR Expansion Joints are available in materials for handling highly corrosive chemicals, wide temperature ranges, and, despite their high strength, have the flexibility of standard joints.

EJ 104

For every industrial rubber product need, turn to US. For Conveyor Belts, V-Belts, the original PowerGrip "Timing"® Belt, Flexible Couplings, Mountings, Fenders, Hose and Packings . . . custom-designed rubber products of every description. Discover why U.S. Rubber has become the largest developer and producer of industrial rubber products in the world. See your U.S. Rubber Distributor or contact US directly at Rockefeller Center, New York 20, N. Y.

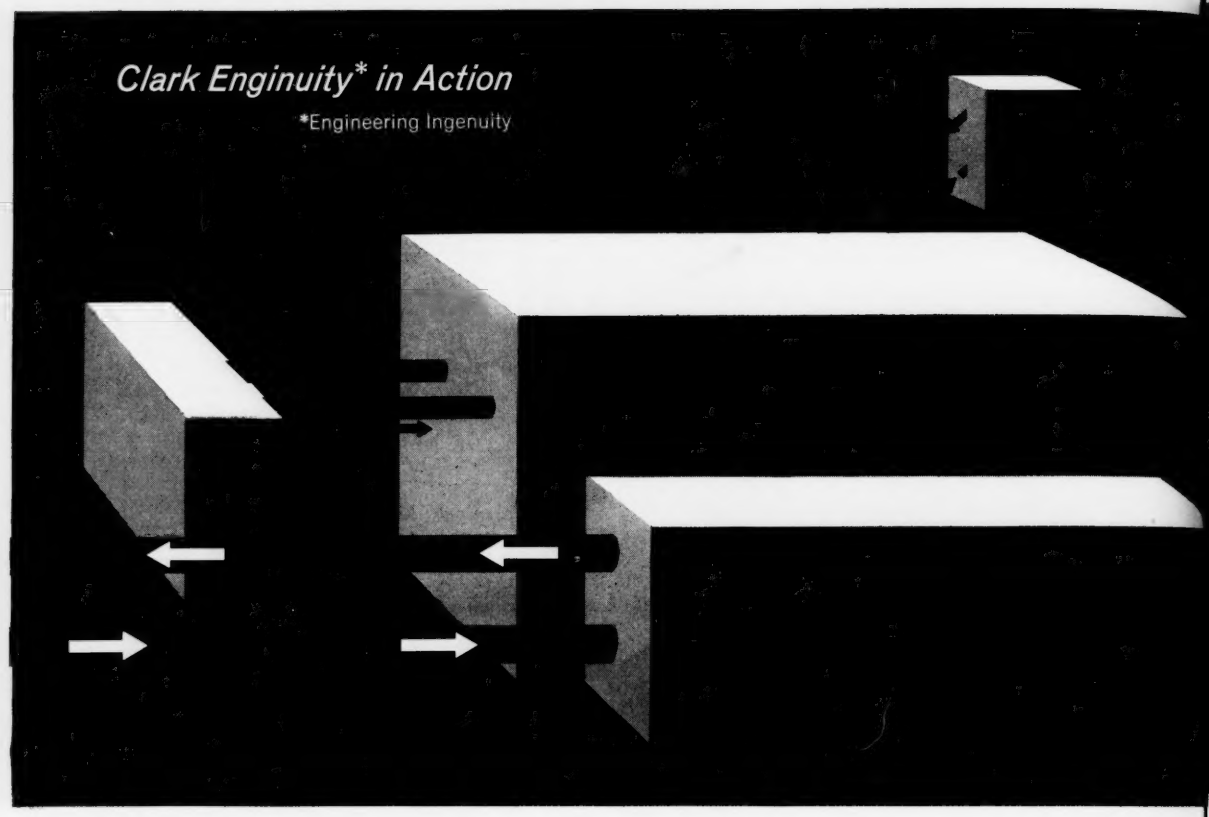
WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

United States Rubber

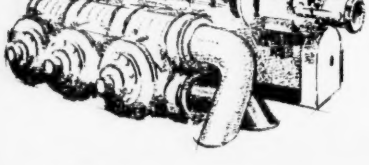
MECHANICAL GOODS DIVISION

Clark Enginuity in Action*

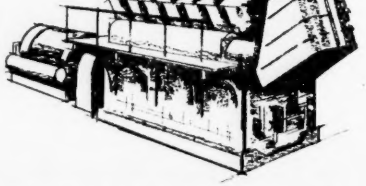
*Engineering Ingenuity



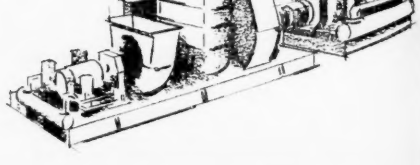
New CLARK MODULAR SYSTEM takes big bite out of compression costs



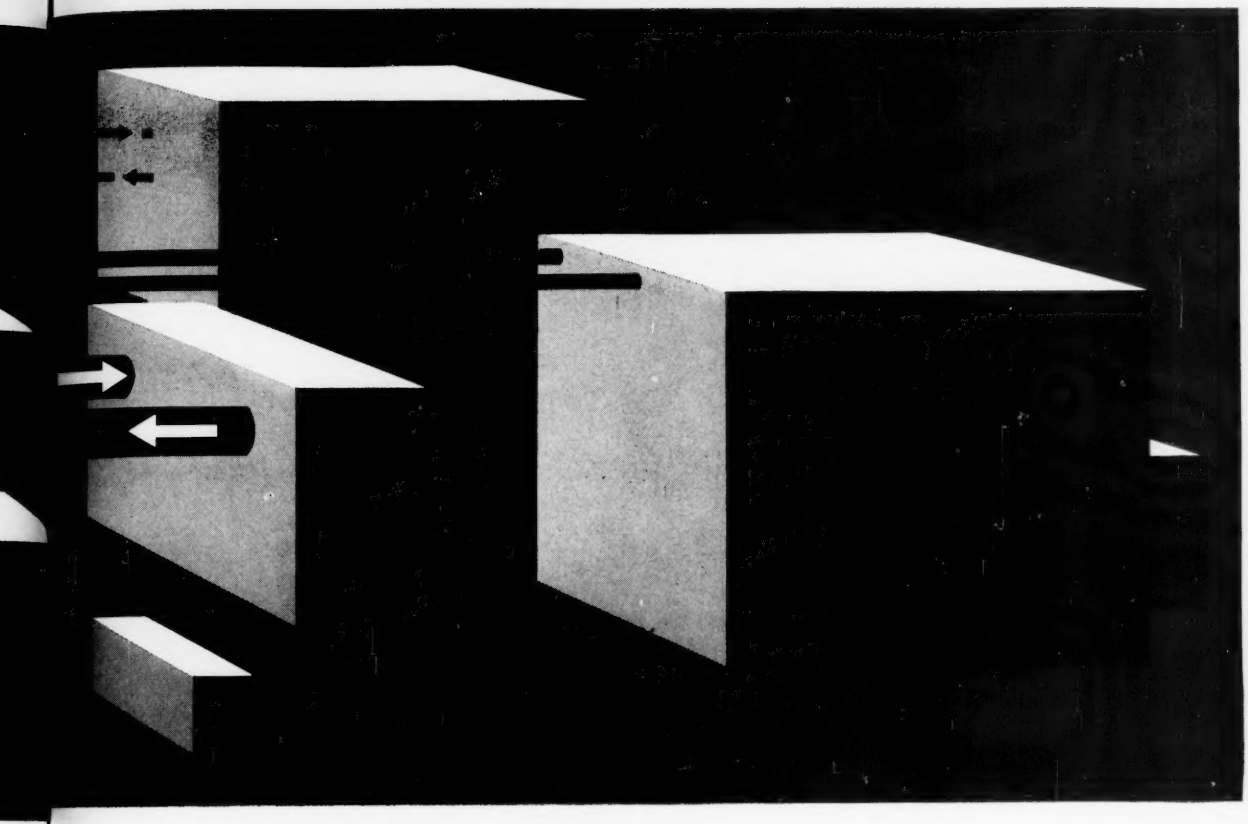
In-Line Gas-Engine-Driven Compressors.



Gas-Engine-Driven Centrifugal Compressors.



Gas Turbine Compressor Units.



Compressor station equipment in modules—That's the latest big news from Clark . . . and it's your cue to one of the soundest, most far reaching proposals ever made for reducing compressor costs.

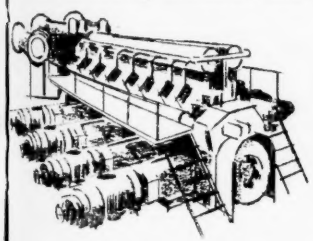
Here's how the Clark modular system works—Taking a look at high compressor station costs, particularly the expensive field labor required to install all the equipment, Clark engineers came up with a bold new manufacturing plan to help operators save money: First, arrange station equipment into related modular systems. Second, engineer and fabricate each module *completely* at the factory under controlled shop conditions and with efficient labor. Third, ship the modules to the job site, ready for quick, easy hookup.

Substantial all-around savings—Startling in its simplicity, the Clark *Modular System* offers numerous opportunities to cut costs. Here are a few:

- Pre-engineering drastically reduces the user's engineering workload and cuts down elapsed time from project go-ahead to startup.
- Field fabrication is sharply reduced. Just locate modules and run piping to and from the driver.
- Delays and other hazards of "cut and try" field installation are eliminated.
- Each module is complete within itself, not dependent upon other systems for satisfactory operation.
- Orientation and location of modules can be varied to suit any installation or terrain requirement.
- The modular system permits compressor installation on a simple, easily poured concrete slab.
- Additional compressors with their accompanying modular auxiliaries can be readily and quickly installed as the station expands.

Sound interesting? Your nearby Clark representative has a remarkable story to tell, complete with facts, figures, engineering drawings and economic comparisons. Contact him today.

CLARK BROS. CO., OLEAN, N.Y.



V-Type Gas-Engine-Driven Compressors.

CLARK® DRESSER INDUSTRIES INC.
OIL • GAS • CHEMICAL
ELECTRONIC • INDUSTRIAL

A working partner in allied industries
PODBIELNIAK *Centrifugal Contactors, Distillation Apparatus, Instrumentation*

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LEADERSHIP IN INDUSTRIAL AUTOMATION

ADDED VALUES

QUALITY CONTROL

Quality control influences every G-E operation, from order receipt to shipment.

PRODUCT INNOVATION

Product research and development is advanced in all 98 G-E laboratories.

SYSTEM PLANNING

Process-oriented application engineers and information-handling-system specialists assist you with systems application and integration.

ANALYTICAL ENGINEERING

The latest tools of process analysis are available for studies of your problems.

INSTALLATION AND SERVICE ENGINEERING

Expert on-site assistance gives you smoother installation and earlier start-up.

SYSTEM CO-ORDINATION

G.E.'s systems experience focuses the full Company capabilities on your order.

NATION-WIDE SERVICE SHOPS

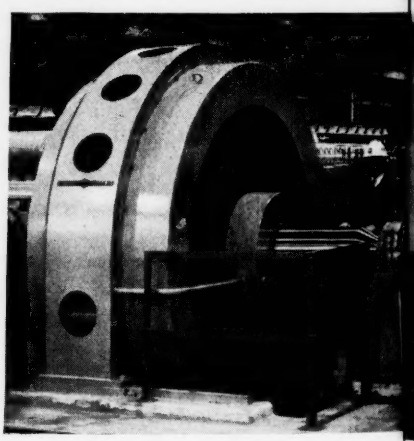
More than 50 G-E Service Shops offer you 'round-the-clock maintenance service.

PROMPT DELIVERY

Accurate delivery cycles put your new G-E equipment to work for you—on time.

VALUE ANALYSIS

Value Analysis gives you optimum combination of product value and economy.



G-E SYNCHRONOUS MOTORS with improved insulation systems operate reliably, reducing equipment downtime. Efficient operation is assured since motors are matched to particular operating requirements.

Increase your operating profits with General Electric Process Control Systems

Improving profitability is a continuing program where the direction is not always obvious. Here is where the manufacturer of a broad line of electrical products can be of great assistance . . . providing current information . . . recommending latest improvements. General Electric's system capability brings to users intimate knowledge of the entire electrical and control system . . . enables users to look to one source for undivided responsibility.

IN THE MAJOR AREAS of sensing, computing, controlling and power actuation, General Electric's capabilities bring advanced design and continual product improvement to the Chemical Processing Industries.

FOR INSTANCE, PROCESS COMPUTERS are now enlarging their potential for these industries. Certain applications may well encompass systems engineering fully utilizing the computer's abilities and capacity to integrate all related functions for greatest system profitability.

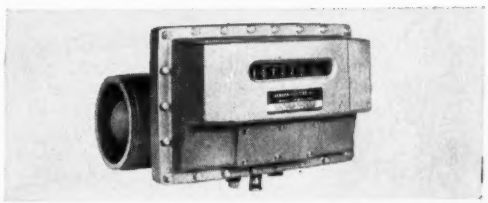
THROUGH THE YEARS, GENERAL ELECTRIC SYSTEMS ENGINEERS have been applying a full range of electrical products and techniques to industry's problems. Today, G.E. has the needed experienced engineers—chemical, system, analytical, computer, x-ray—*plus* unexcelled technical resources—to perform outstanding work in applying comprehensive process control systems.

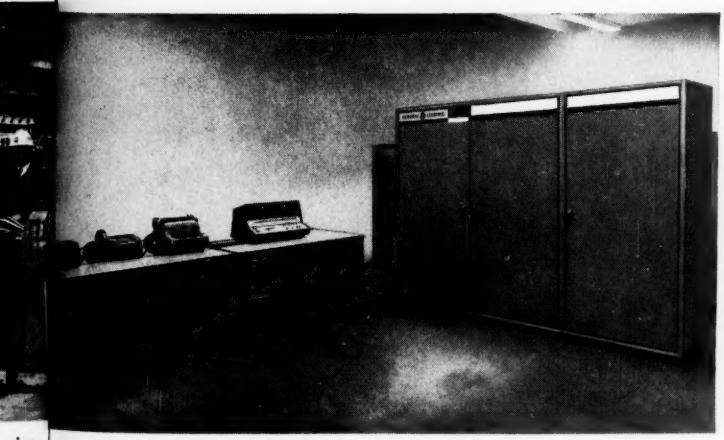
In the face of ever-stiffening competition in the Chemical Processing Industries, those who take full advantage of today's advanced technologies will be in the best position to ensure tomorrow's profits. For additional information, call your local Industrial Sales Office. General Electric Company, Schenectady 5, New York. 651-05

Progress Is Our Most Important Product

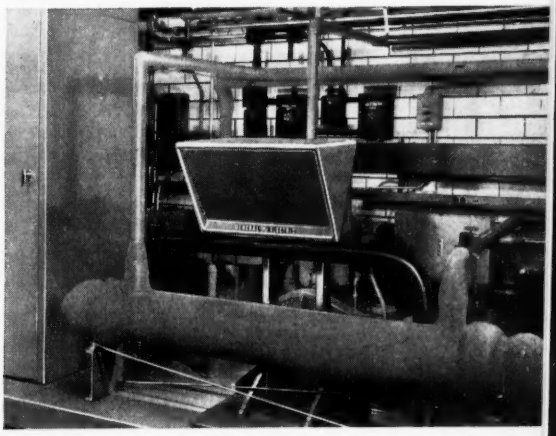
GENERAL ELECTRIC

NEW TRUE MASS FLOWMETER—Accurately measures the flow of liquids or gases directly in pounds despite wide variations in temperature, viscosity and other variables . . . used as part of G-E indicating, recording and telemetering systems.



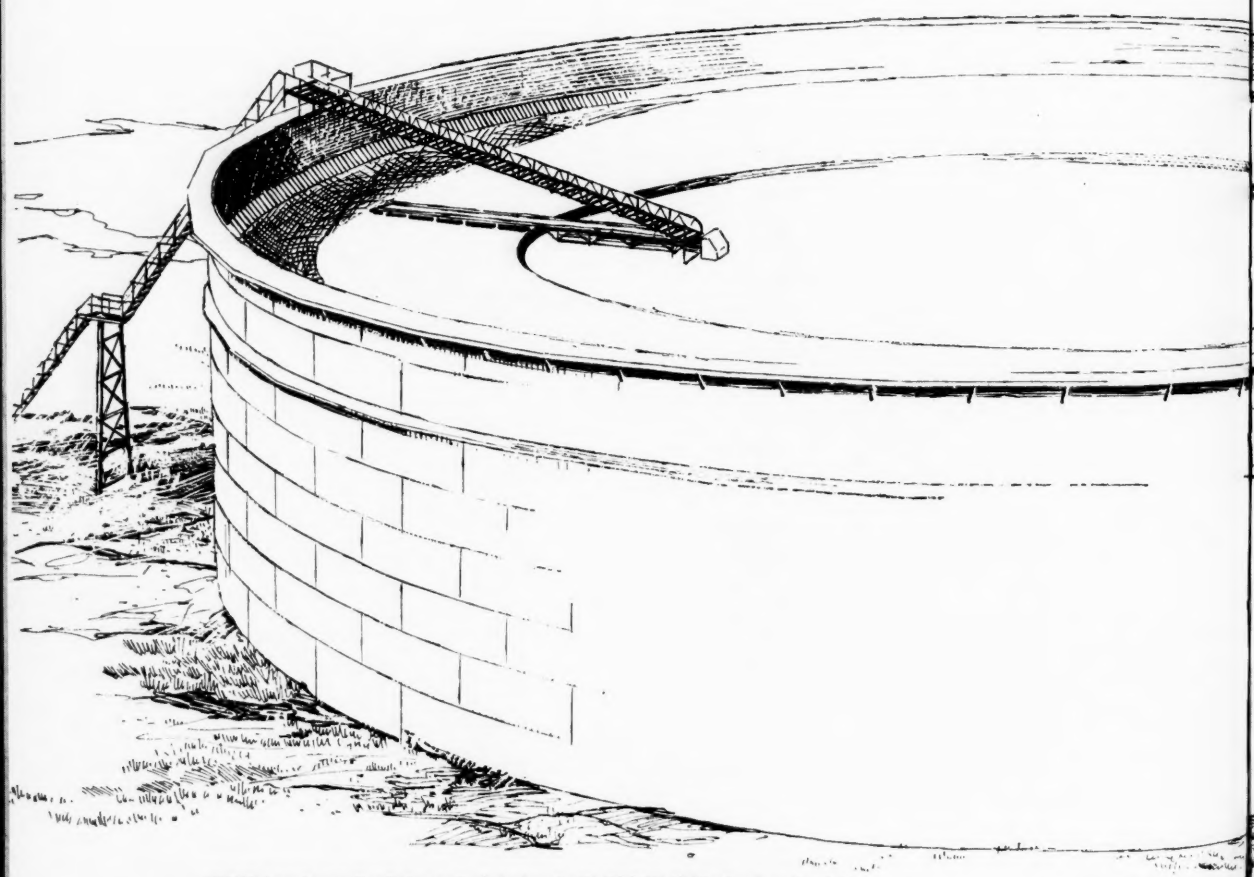


312 and GE 412 COMPUTERS provide wide application flexibility. From ta logging and monitoring of a single process to central dispatching in a mplex multi-computer system, General Electric's process computers provide answer to the increasing complexity of today's industrial applications.



G-E XEG X-RAY EMISSION GAGE is an "on-line laboratory" for quality control. XEG performs continuous analysis of solids, liquids, liquid mixtures, slurries, powders, or similar materials during production.

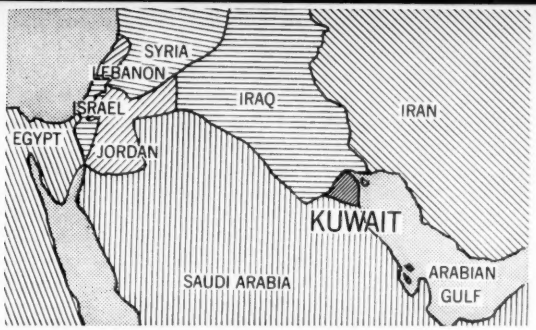
World's largest oil storage tank built



600,000-barrel capacity oil storage tank designed with USS "T-1" Steel reduced weight by about 42%, with substantial savings in fabrication, freight and erection costs.

This mark tells you a product is made of modern, dependable Steel.

USS "T-1" Steel



A new 600,000-barrel oil tank 260 feet in diameter and 64 feet high has been erected for the American Independent Oil Company in Mena Abdulla, Kuwait, on the Arabian Gulf.

Kuwait is a petroleum paradise. In 1957, its oil production amounted to 56,000,000 tons, and it is still increasing. Most of the oil is exported and a giant storage tank such as this makes it possible to fill one of the new super tankers in one stop, rather than several.

The Chicago Bridge & Iron Company obtained the contract for the tank with a design that took advantage of the *extra* high strength of USS "T-1" Constructional Alloy Steel and its many cost-saving features.

The shell consists of six 8-foot rings of "T-1" Steel, made to 115,000 psi minimum ultimate strength, and two top 8-foot rings made of A 131 grade A carbon steel. The tank has a Horton pontoon floating roof and the bottom of the vessel was made of A 283 grade C plates ¼-inch thick.

USS "T-1" Steel reduces weight. The "T-1" shell thicknesses, which ranged from 1 inch down to ½ inch, were determined on the basis of a design stress of 38,333 psi. This is ⅓ of the minimum ultimate strength of the steel. Joint efficiency was calculated at 100%, with a product specific gravity of 0.90. The top two carbon steel rings were figured for the API 12-C allowable stress of 21,000 psi, with 100% joint efficiency, and with a product specific gravity of 1.0. Steel thicknesses were ½ inch and ⅜ inch.

Although API prohibits the use of carbon steel plates in the thicknesses that would have been needed for the 6 lower rings, by using USS "T-1", 42% less steel was required. Fabricating, shipping, and erecting costs were thus considerably lower than original estimates.

Lower maintenance, too! USS "T-1" Steel has four times the resistance of carbon steel to atmospheric corrosion. Research has shown that paint life is greatly increased on steels of this nature.

Other applications. Because of USS "T-1" Steel's exceptional strength and toughness, even at very low temperatures, it is the ideal material for pressure vessels, equipment hauling trailers, LP gas transports, offshore rigs and other equipment that must be built stronger but lighter. Write for a copy of our booklet, USS "T-1" Steel. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and "T-1" are registered trademarks of United States Steel
"Horton" is a registered trademark of Chicago Bridge & Iron Company

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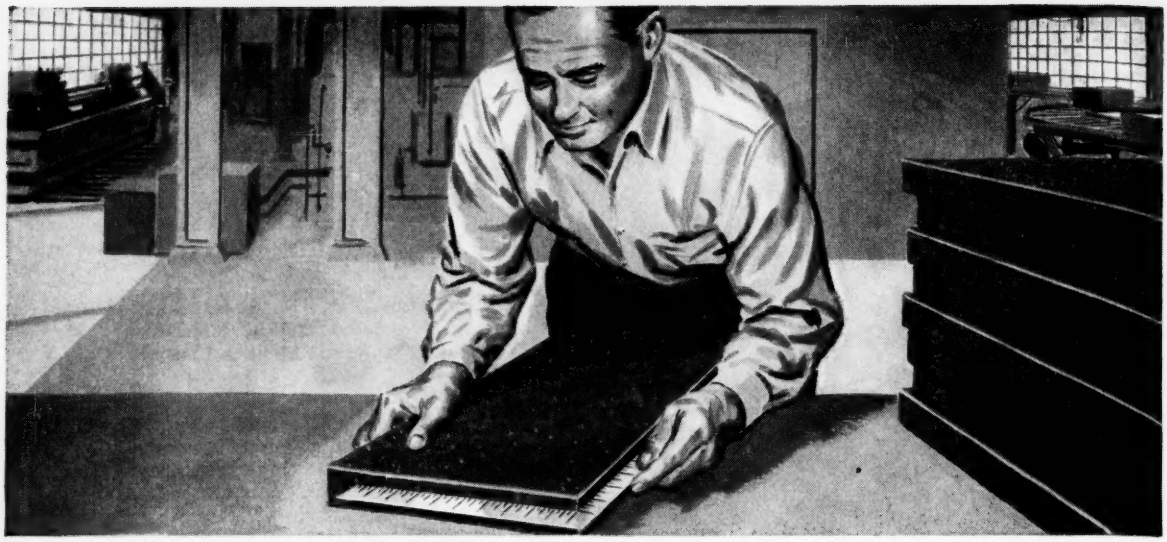
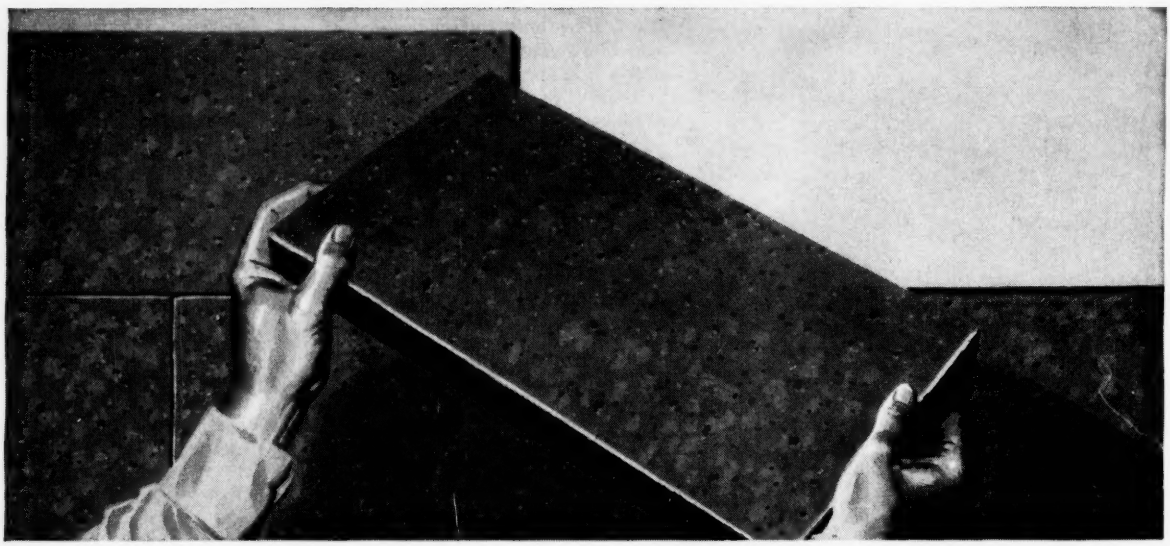
United States Steel



A TRUE-CUT BLOCK WITH PRECISION-FINISH!



- Eagle-Picher's "precision-finish" is one of the most important insulation developments in years.
- Highly efficient, all-purpose block that is practically dustless.
- Great structural strength! Meets rigid demands for long-lasting block able to withstand wide temperature range up to 1900 F.
- Lightweight, easily installed! Easily cut to fit irregular areas—no special tools needed. Requires only minimum reinforcing.
- Effectively resists steam and other moisture! Does not disintegrate or lose thermal efficiency under heavy duty service.

EAGLE-PICHER
PV SUPERTEMP
BLOCK INSULATION

This Mineral Wool Insulation conforms to COMMERCIAL STANDARD CS-117-49 as issued by U.S. DEPARTMENT of COMMERCE.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

EAGLE-PICHER / Manufacturer's Manufacturer

Since 1843 / The Eagle-Picher Company
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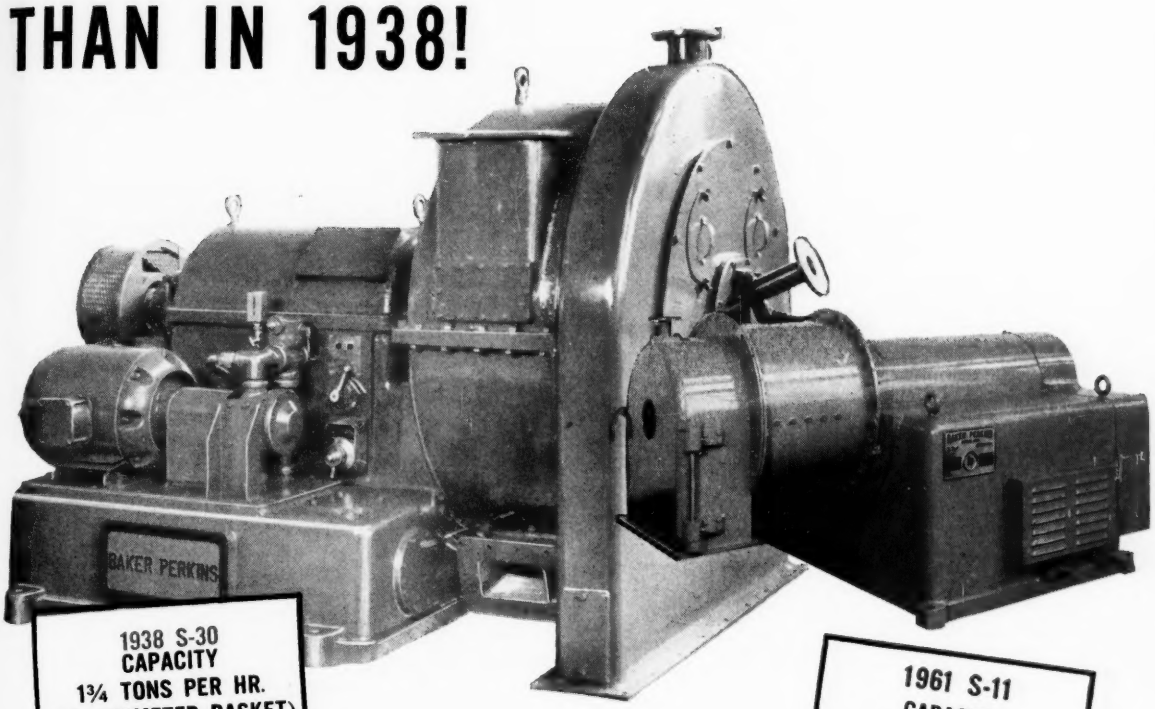
Cincinnati 1, Ohio

EAGLE EP PICHER

B-P CENTRIFUGALS COST NO MORE TODAY PER TON OF CAPACITY THAN IN 1938!



1938 S-30
CAPACITY
1¾ TONS PER HR.
(30″ DIAMETER BASKET)

1961 S-11
CAPACITY
5¼ TONS PER HR.
(11″ DIAMETER BASKET)

Chemical processing equipment costs have risen tremendously in the last 23 years yet the price of the new B-P S-11 centrifugal-based on the capacity in tons per hour—is the same as it was way back in 1938! Compare the two machines above . . . the new S-11, while much smaller than the old S-30, discharges 3 times as much dried solids.

One unit does the work of three, which means that other expenses such as installation cost, power cost and floor space are drastically reduced.

Cost-minded production men know lower production costs mean a better profit margin. Baker Perkins would like to show you how this machine can make a better product at a lower cost. Why not contact your B-P Sales Engineer for complete information.

SEE B-P EQUIPMENT
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the Chemical Industries
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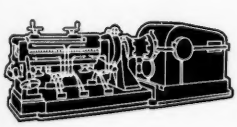
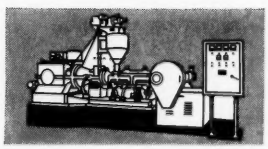
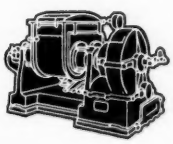
BAKER PERKINS INC.







CONTINUOUS MIXERS • PLASTICS MACHINERY • UNIVERSAL MIXERS

410

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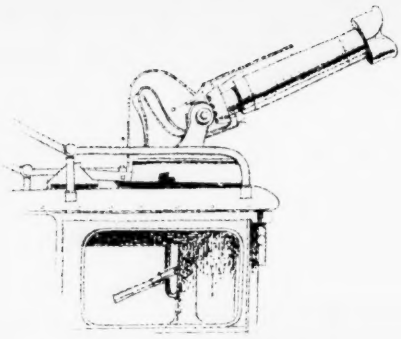


ROCKWOOD DELIVERS MORE FIRE FIGHTING POWER—

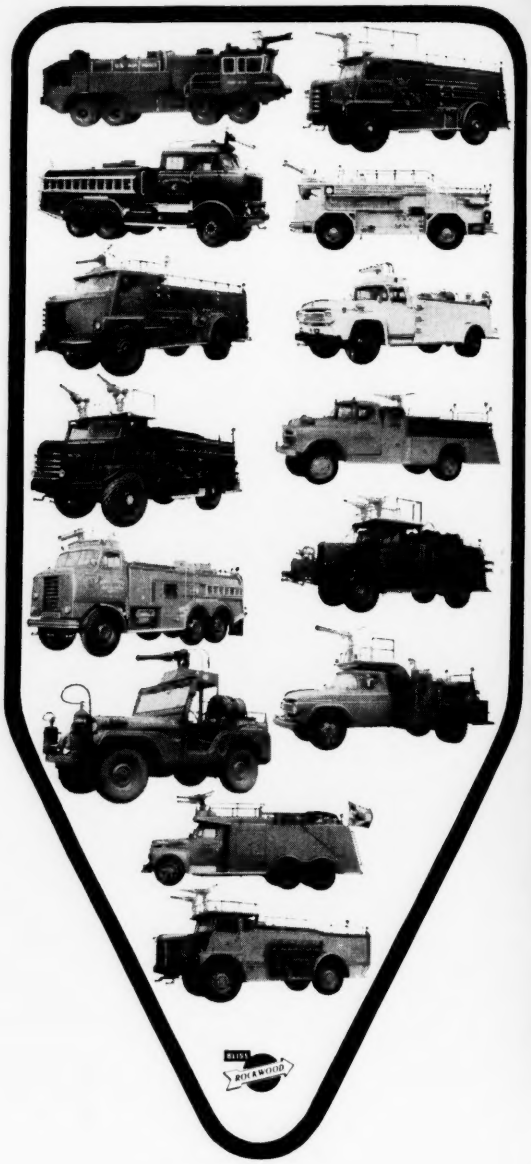
extinguishes faster

Rockwood specialty FOAM Fire-Truck equipment provides greater fire-fighting punch to meet any situation fast and make manpower more effective! Why? Because it adapts quickly to changing conditions . . . hits harder and faster.

There's volume and versatility to spare in Rockwood turret nozzles. They are immediately adjustable to fight fire four ways: with FogFOAM — Solid FOAM Stream — WaterFOG — Solid Water Stream.

And Rockwood FOAM Fire Truck Proportioning Systems provide close control of FOAM liquid proportioning *automatically* — another vital step in the efficient use of manpower.

Rockwood Handline, Ground-sweep, Under Truck Nozzles and custom designed specialty parts combine to round out the complete line of FOAM equipment . . . the most advanced, most effective tools for fire protection, regardless of your particular needs. For details, write Rockwood Sprinkler Company, Portable Fire Protection Department, 525 Harlow Street, Worcester 5, Mass. Distributors in all principal cities. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E.W. Bliss Company. *Rockwood engineers water . . . to cut fire losses.*



ROCKWOOD

PORTABLE FIRE FIGHTING EQUIPMENT

THIS 45 FT. PRESSURE SPHERE HOLDS 2000 TONS OF LIQUID CHLORINE AT –30° F

Serving Pittsburgh Plate Glass Company's Chemical Division at New Martinsville, West Virginia, this very large double-shell sphere is yet another of the many current examples of PDM craftsmanship in low-temperature storage facilities. The chlorine-containing inner sphere is of A 203 steel. Annular space between this sphere and the outer steel shell is filled with foamglass and perlite insulation; heat transmission is held to a very low rate, and the –30°F storage temperature is easily maintained. If you have a liquefied gaseous product to contain in large quantities, PDM's cryogenic experience is at your service. Let us discuss your requirements, and provide prompt quotations.

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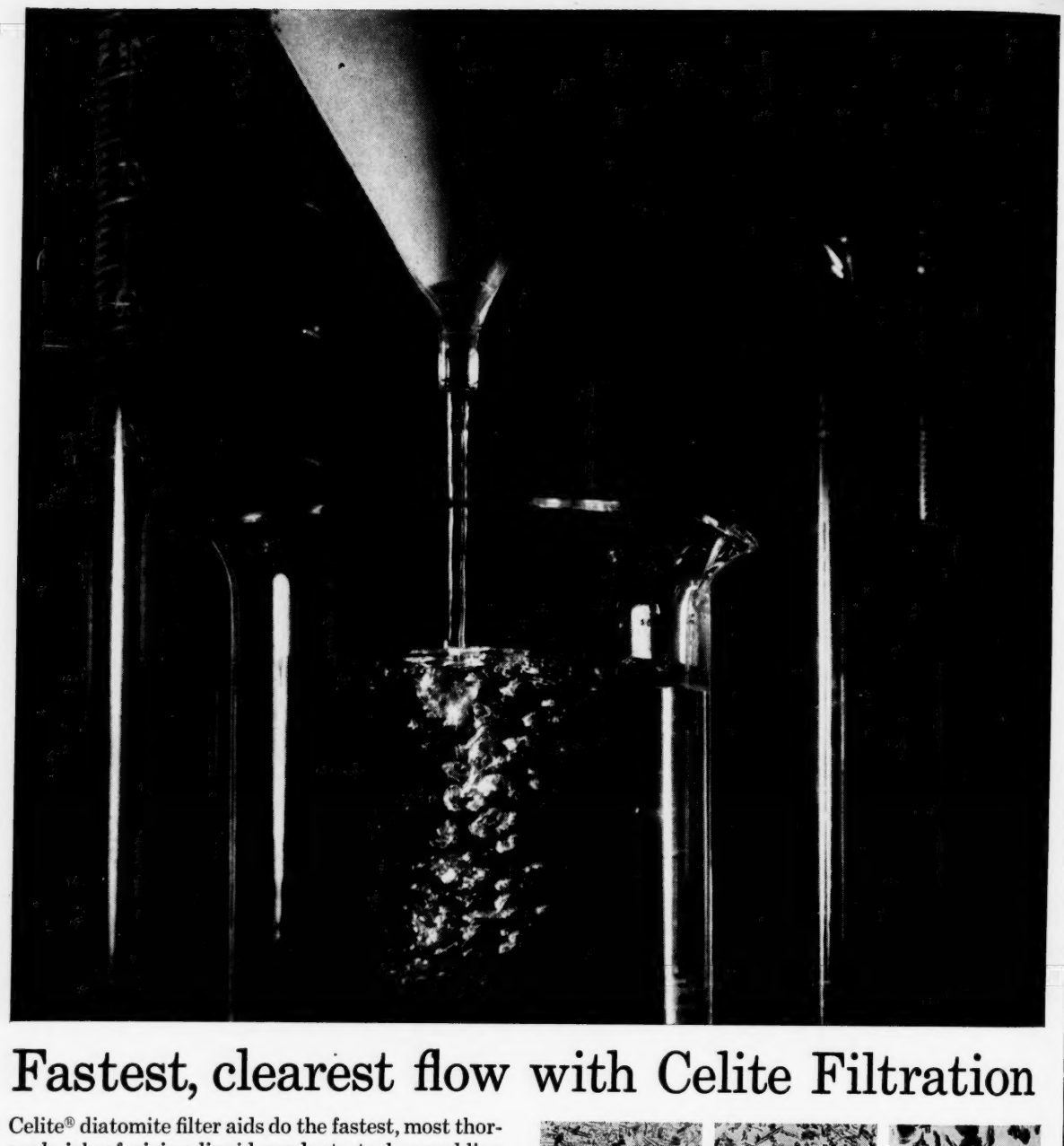


Fastest, clearest flow with Celite Filtration

Celite® diatomite filter aids do the fastest, most thorough job of giving liquid products truly sparkling clarity. Because of its unique particle structure and highly irregular particle shapes, Celite filters out the most minute solids at the fastest flow rates obtainable. Product quality goes up and production costs go down.

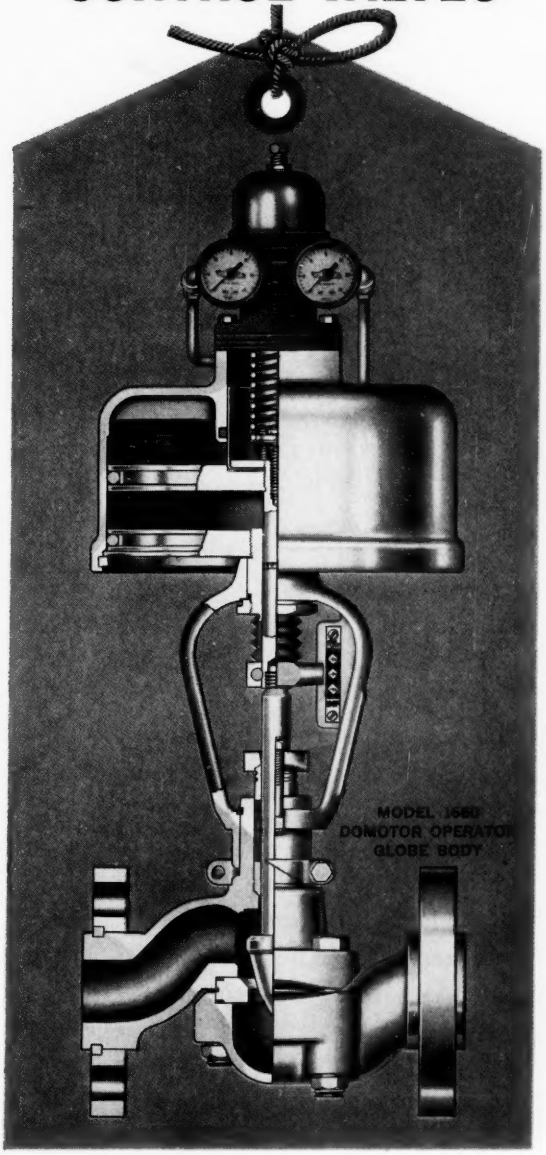
Processed from the world's largest and purest diatomite source, Celite has the highest degree of uniformity in the industry. What's more, with the widest selection of standard and special grades to choose from, you're assured of getting the exact degree of clarity needed.

For full details, write Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario. Cable address: Johnmanvil.

These photomicrographs show the range of characteristics available with Celite filter aids.

JOHNS-MANVILLE

WHY ANNIN IS THE CHEMICAL INDUSTRY'S LEADING SUPPLIER OF CONTROL VALVES



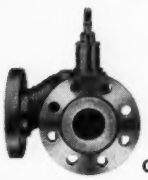
Annin control valves have been designed with the needs of the process industries in mind. The split body, single seat construction reduces body turbulence and erosion, gives longer life. The interchangeability of Annin valve components, the easily replaceable trim, the option of angle or 3-way bodies carried in stock for immediate shipment, simplifies your installation and maintenance problems. The flexibility in basic design cuts down on the valve parts inventory ordinarily required for a variety of plant applications. Another factor is the $1½ million in alloy body parts regularly carried in Annin stock, including a wide range of 300 series stainless steels, Hastelloys, Monel, Inconel, Durimet-20, and a variety of bronzes. If reduced valve inventory, design flexibility, and economical maintenance are factors in your operation, we suggest you investigate the advantages inherent in Annin process control valves.

ANGLE BODY

For fluid problems involving solids in suspension, high viscosity fluids, and applications requiring special nozzle materials or design.

3-WAY BODY

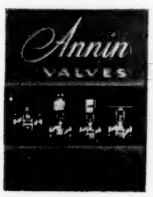
Provides two horizontal line connections and an individual bottom vertical line connection. Sections may be rotated for convenience.



CORNER BODY

Standard for body sizes ½"–2". Often used to replace expensive alloy ells, this body simplifies installation and conversion on the job.

ANNIN DESIGN FLEXIBILITY reduces inventory...simplifies installation and maintenance...as no other control valve can!



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DELIVERY: Often a challenge!

Delivering this 165 foot, 135 ton fractionating tower on schedule often had its moments.

Built by Sun Ship for a petrochemical company's gas-processing operations, this giant tower presented quite a challenge enroute. Passing through narrow bridges with mere inches to spare, became routine.

But we're used to handling unusual situations. We specialize in designing and building to the most unique requirements. You can be sure of precision engineering and construction on any type of project, from intricate equipment to cargo ships.

Our diversification applies to delivery also. Besides our experience with railroads, being on the hub of the Delaware River makes us a natural for shipment by water.

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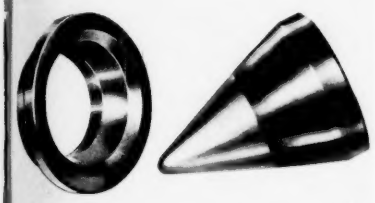
U.S.I. CHEMICAL NEWS

November A Series of Advertisements for the Chemical Process Industries 1961

Hard Carbides Answer Need For More Rugged Materials In Chemical Processing

The hard carbides, particularly those of tungsten and titanium, are becoming more firmly established as materials for critical components in chemical processing equipment. Increased application is expected because these carbides have properties that cannot be equalled by other structural materials.

These hard carbides have high wear



Valve components of hard carbides had 20 times service life of second best material in regulating pressure drop of 900F gases carrying aluminum oxide catalyst.

and corrosion resistance, excellent rigidity, high strength, and high-temperature properties. Thus they reduce maintenance, increase operating efficiency and even make new processes possible by permitting higher combinations of temperature, pressure, flow rate or volume.

Chemical Applications

Among current chemical industry applications for hard carbides are nozzles for such equipment as centrifuge separators, drying towers, emulsifiers; valves for reci-

(Continued on next page)

UDMH Data Published

Comprehensive data on unsymmetrical dimethylhydrazine (UDMH) have been compiled in a two-page article appearing in a recent issue of *Chemical Engineering Progress.*

The paper, written by Louis H. Diamond of FMC Corporation, covers physical properties, manufacturing processes, purification methods, storage and handling, materials of construction that can be used with UDMH, and its propellent applications. FMC Corporation is a partner with U.S.I. in a new plant to produce UDMH in multi-million pound quantities.

For a reprint of the paper, write Technical Literature Dept., U.S.I. Chemical News, 99 Park Ave., New York 16, N. Y.

Stabilization, Valve Developments Broaden Aerosol Markets

Propellant Additive Stabilizes Alcohol-Based Products; New Valve System Opens Way for Aerosol-Dispensed Anti-Perspirants

Recent advances in aerosol technology reportedly eliminate problems in pressure-packaging two important classes of products: alcohol-based formulations and anti-perspirants. Nitromethane has been found to be effective in stabilizing alcohol-containing aerosols against metal container corrosion. And a new non-metallic valve and closure has been designed which minimizes clogging caused by drying out of aluminum salts used in most anti-perspirant and deodorant formulas.

Both developments are seen as broadening the market for aerosols. Up to now, for example, the corrosive action of personal product formulas containing alcohol with propellant 11 has generally precluded packaging in aluminum containers. Aerosols have not made any dent in the anti-perspirant field, which represents an estimated market in excess of 93 million packages with a retail sales value of over $95 million.

Free Radical Inhibition

The development of an effective stabilizing agent for alcohol-based aerosols resulted from extensive research. An early premise was that hydrolysis was the cause of corrosion. But tests revealed that the distortion of odor, development of acidity and, ultimately, corrosion of the container were due to a free radical reaction of trichlorofluoromethane, or propellant 11, with ethanol. This has been substantiated

(Continued on next page)

New Composite Polyethylene Container Saves Money For Chemical Company

Polyethylene drums with wirebound overwraps have reduced initial container costs 60 per cent and lowered overall packaging, handling and shipping costs for a major chemical distributor.

Where possible, the company switched from 13-gallon glass carboy cases to relatively inexpensive composite containers for chemicals. The new packages consisted of 15-gallon polyethylene drums in octagonal protective wirebound overwraps.

In addition to savings on initial container costs, the new containers increased pallet capacity by over 125 per cent in gallonage and doubled it in number of containers. They also reduced storage area requirements since pallets could be high-stacked. This was made possible by designing the overwrap so that the protruding neck of the polyethylene drum is just below the level of the end cleats. And shipping container tare weight was cut from a previous 70 pounds to 15.5 pounds, with comparable savings in shipping charges.

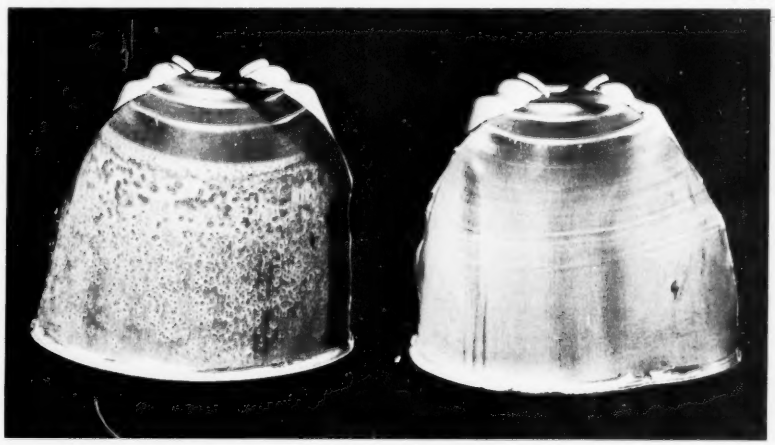


Photo courtesy E. I. du Pont de Nemours & Co. Inc.

Corrosion control by nitromethane shown by two aerosol cans subjected to same tests. Can at left contained alcohol/propellant 11; at right, alcohol/propellant 11 plus nitromethane.

National Distillers, Cerro Join in Primary Aluminum Feasibility Study

Cerro Corporation and Bridgeport Brass Company Division of National Distillers and Chemical Corp. have announced a joint study of the feasibility of an aluminum reduction plant of 56,000 tons annual capacity at Wauna, Oregon.

Though a decision whether to undertake the project will be made on completion of the study and on a satisfactory arrangement for financing, a 20-year contract for 90,000 kw of electrical power already has been signed by Cerro.

The proposed plant will employ the conventional aluminum electrolytic reduction process and use prebaked carbon electrodes produced at the site. U.S.I.'s extensive background in the technology of metals reduction will make important contributions to the study.

Hard Carbides (Continued)

procating pumps and use in pressure-relief, pressure-regulating, flow-regulating or other service; seats, stem rods and impact rings of homogenizers; seals and rings; pump bodies and components; liners for steel cylinders for compressed petroleum gases.

Powder-Metallurgy Materials

Hard carbides are powder-metallurgy products, made of the carbides of refractory metal elements, combined with a lower melting-point matrix material. Most common of these is tungsten carbide, cemented with varying amounts of cobalt. Composition is varied by adding the carbides of titanium, tantulum, niobium and chromium. These modify properties to meet particular operating conditions.

Six basic types are available for process-industry components:

- Straight tungsten carbide-cobalt, with properties named above.
- Tungsten carbide-cobalt with TiC, TaC, NbC to improve gall resistance or high-temperature properties.
- Titanium-base carbides with nickel or nickel-molybdenum binders for light weight, resistance to high-temperature oxidation, greater strength at 1800F and above, and high stiffness-to-weight ratio.
- Tungsten carbide with chromium-cobalt binders for combinations of moderate corrosion and wear.
- Tungsten carbide with platinum binder for extremely corrosive conditions involving some wear.
- Binderless carbides of tungsten and tantulum for the ultimate in wear and corrosion, but limited strength and impact resistance.

Aerosol Developments *(Continued)*

in U.S.I.'s research laboratories. The reaction:

$$CCl_3F + CH_3CH_2OH \longrightarrow CHCl_2F + CH_3CHO + HCl$$

Although it was established that air can retard the degradation process, this attack on the problem had drawbacks. Further investigations proved that nitromethane, added as a 0.3% solution in propellant 11, filled all the requirements. Such a stabilized propellant mixture, now commercially available, is believed to be compatible with most non-pharmaceutical aerosol products now on the market.

Use of the new stabilized propellant formulation appears especially advantageous for such aerosols as hair sprays and other personal products, room deodorants, and plant sprays. Government approval will be required before pharmaceutical products utilizing it can be sold.

Details of Valve System

The new, non-clogging valve system features a self-sealing cap, which acts as a "cork" for the aerosol package between uses—thereby minimizing crystallization of the aluminum salts.

Outside, the cap looks like any other. The clue to its effectiveness is inside. It's tapered to seal against the sides of the toggle-type actuator, and it has a projection which fits snugly into the spray orifice. In addition, ribs along the inner sides snap onto the valve cup. Both actuator and closure are made of low-density polyethylene.

The valve, also non-metallic, is said to produce an unusually fine spray and reduce the "chill" associated with aerosols. The system is expected to be used with adhesives, as well as anti-perspirants.

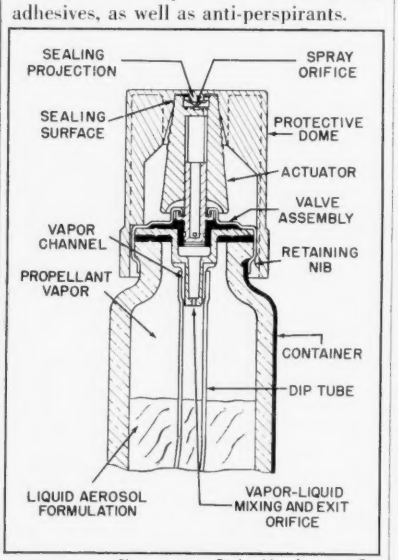


Photo courtesy Risdon Manufacturing Co.

New aerosol valve and closure developed for packaging anti-perspirants.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Two new anionic surface-active agents, alpha-sulfopalmitic and alpha-sulfostearic acids, are available in pilot plant quantities. Among applications are detergents (including bars), greases, flotation agents. **No. 1770**

Three new synthetic rubber developments have recently been described: ethylenepropylene rubber, a promising tire material; *trans*-1, 4-polyisoprene, a synthetic balata; and an improved method for making vinyl pyridine compounds. **No. 1771**

New preparative gas chromatograph lets chemist prepare ultra-pure organics without lengthy analytical distillations or separate samples of up to 10 ml and recover separated components for further study. **No. 1772**

Translation of chemical names into molecular formulas has been accomplished by electronic computer, using a newly constructed grammar of chemical nomenclature. Seen as aid to classifying, indexing, teaching nomenclature. **No. 1773**

Adjustable-flow polyethylene bottle for hydrofluoric acid has patented closure which lets user "dial" the rate of flow—from a single drop to steadily controlled stream. One-pound container has slip-on dust cover. **No. 1774**

Two new groups of surfactants have been developed: high-molecular-weight heterocyclic nitrogen compounds (fatty imidazolines) and a water-soluble amphoteric series. Uses are in cosmetics, textiles, drugs, metals and petroleum. **No. 1775**

Vanadium trichloride (98+% pure) and vanadium tetrachloride (95+% pure) have been introduced in pilot plant quantities. Suggested uses include catalysts, organometallic intermediates, production of high-purity metals and intermetallics. **No. 1776**

Soviet research papers on electrolytes will be sold in a 110-page English translation. A collection of 21 papers covering electrochemistry of molten and solid electrolytes, the volume includes new data and methods. **No. 1777**

New metal plating compounds are applied by brush, spray or immersion without electric current. Said to give aluminum corrosion protection and decoration superior to anodic and conversion coatings. For wide range of metals. **No. 1778**

Non-separating benzoyl peroxide paste is now being offered in an improved formulation. Said to have these advantages as polymerization catalyst over standard formulations: fire resistance, even consistency, complete homogeneity. **No. 1779**

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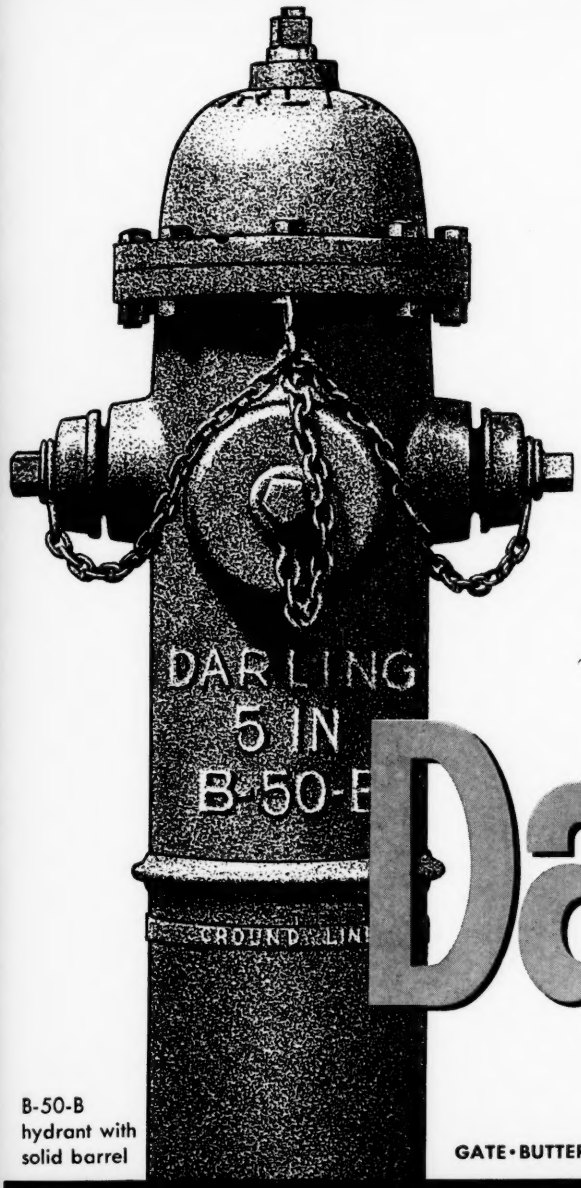

B-50-B hydrant with solid barrel

performance HIGH
operating costs LOW

Available in many types for usual and unusual services, Darling Hydrants provide that dependability, ease of operation, and minimum maintenance that keeps overall costs *low*, performance *high!*

The B-50-B design, for example, combines ball bearing operation with "O" ring seals—assures a trouble-free, easily operated, dry-top hydrant. Threads and bearings stay lubricated—water can't reach them. There's no packing gland maintenance—ever! And the B-50-B design is available in all types except the Tropical. *You can depend on* Darling Hydrants for maintenance-free, trustworthy service.

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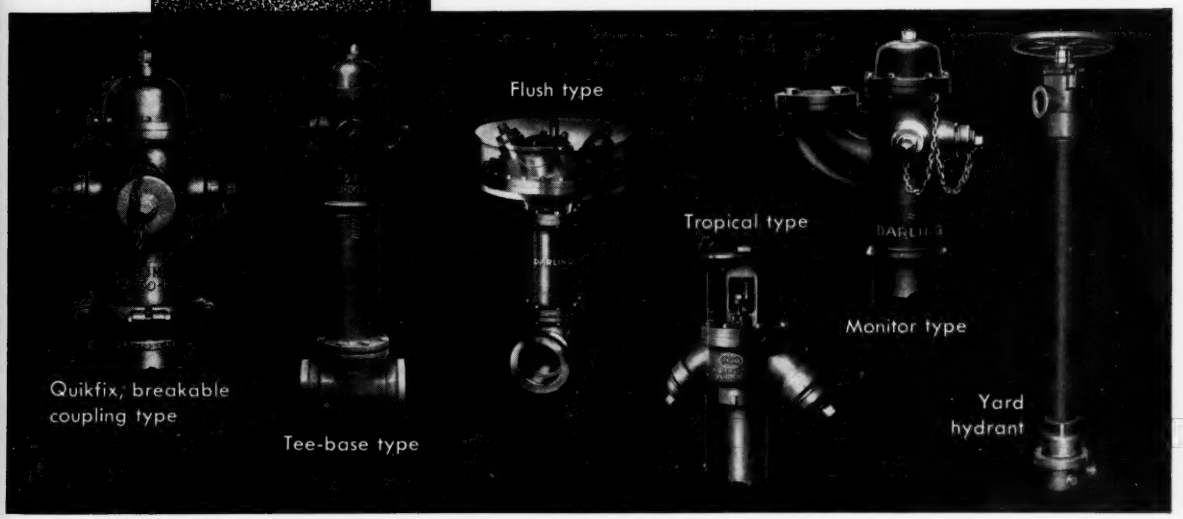

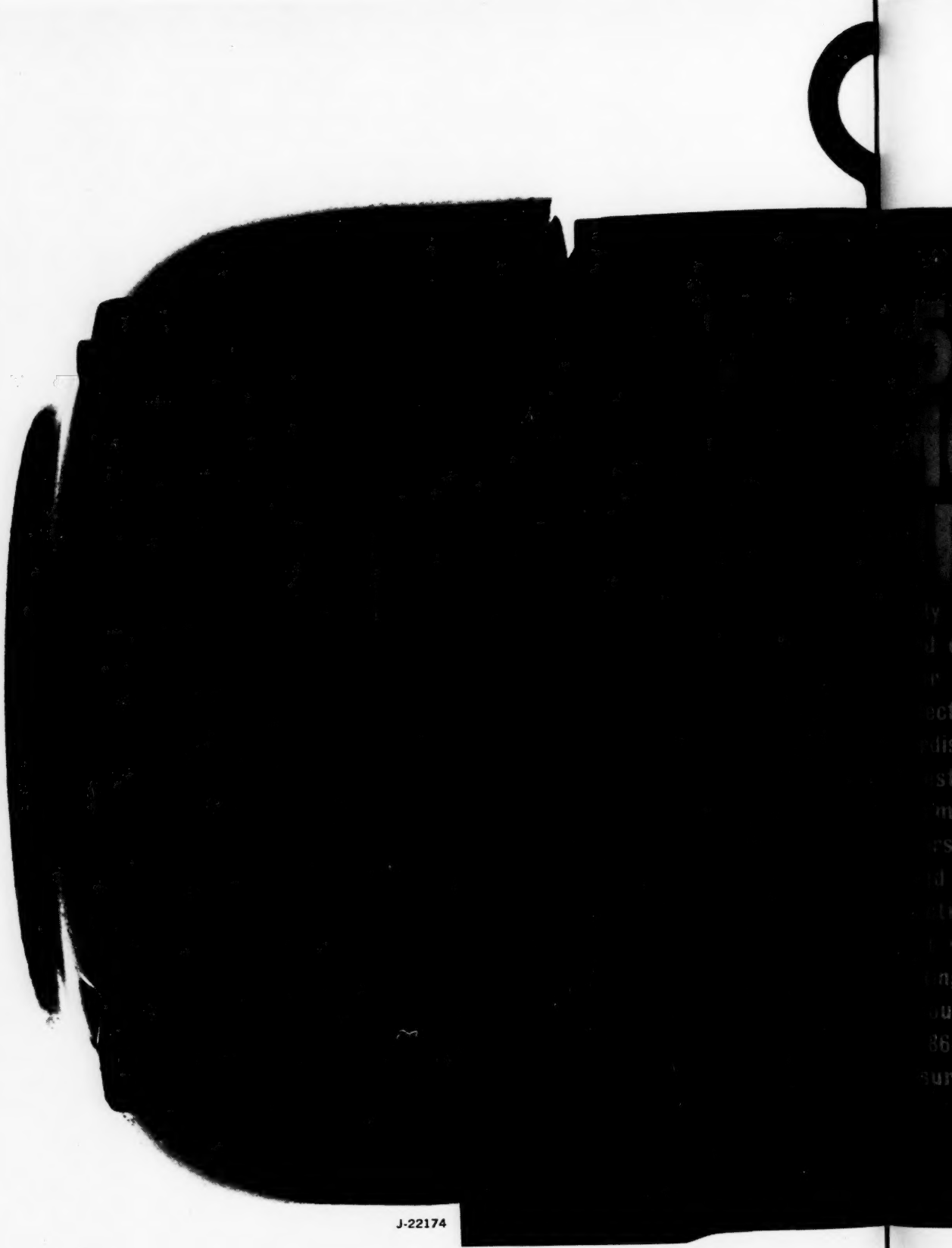

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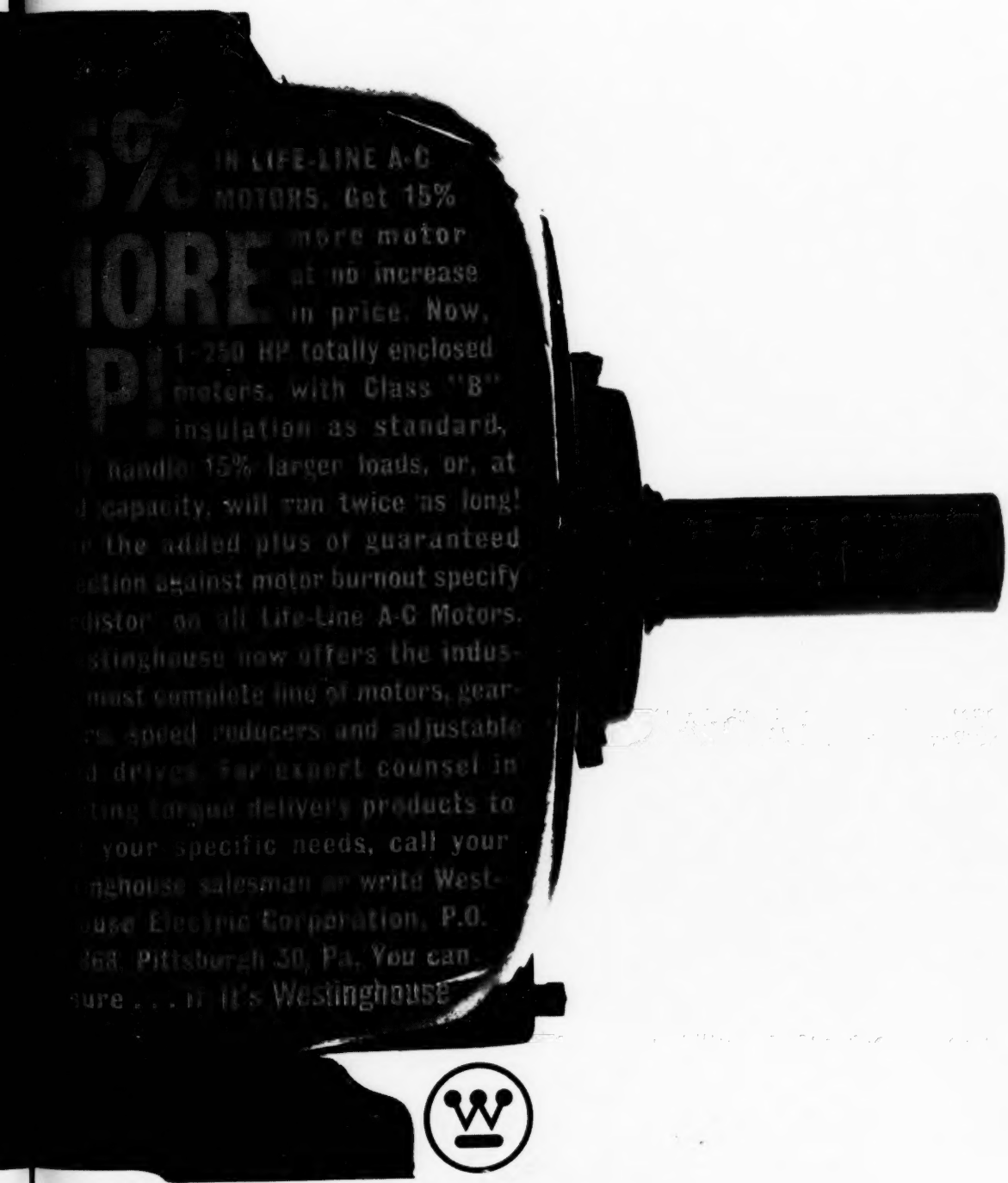
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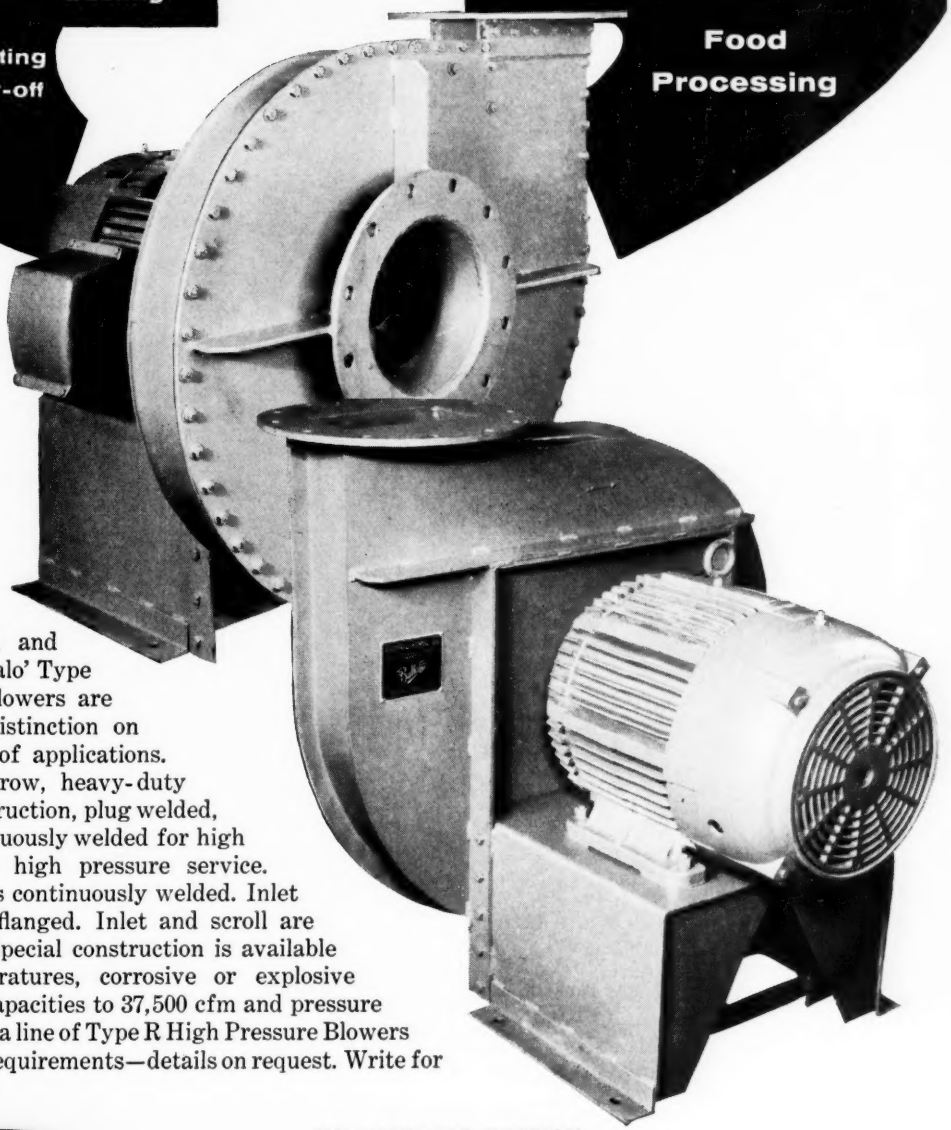
Food Processing



Rugged, ribbed and gas-tight, 'Buffalo' Type CB Pressure Blowers are serving with distinction on a wide variety of applications. Wheels are narrow, heavy-duty steel plate construction, plug welded, riveted or continuously welded for high strength under high pressure service. Housing scroll is continuously welded. Inlet and outlet are flanged. Inlet and scroll are mastic sealed. Special construction is available for high-temperatures, corrosive or explosive atmospheres. Capacities to 37,500 cfm and pressure to 74" w. g. Also a line of Type R High Pressure Blowers for specialized requirements—details on request. Write for Bulletin FI-310.

AIR HANDLING DIVISION

BUFFALO FORGE COMPANY

Buffalo, New York

Canada Pumps Ltd., Kitchener, Ontario

'Buffalo' Air Handling Equipment to move, heat, cool, dehumidify and clean air and other gases.

'Buffalo' Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.

'Buffalo' Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.

Squier Machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.

Take a tip from Cinderella

With the help of a Fairy Godmother, Cinderella had no difficulty finding a coach-and-four, footmen and even a husband. But today, with the help of Sinclair petrochemicals. manufacturers are creating products more wondrous than even Cinderella's Fairy Godmother could dream of.

For example. in the plastics and synthetic fibres industries, Sinclair petrochemicals are indispensable raw materials being used in the development of countless new and exciting products. Even when you add the new developments in paints. fertilizers. insecticides and detergents. you've only scratched the surface of profitable opportunities.

Sinclair supplies petrochemicals in both quality and quantity. Shipping and production schedules are set up to meet the most stringent demands. The purity of Sinclair petrochemicals sets industry standards.

SINCLAIR PETROCHEMICALS, INC.

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Top news stories and what they mean to CPI technical decision-makers

Chementator

Longer resin chains are key to preparing "one-can" epoxy coatings

Shell Chemical Co. has just introduced the first epoxy surface-coating system that needs no curing agent. The trick: employing a high-molecular-weight resin (200,000 av. wt.) that gives an epoxy's usual toughness and bonding power without the need for cross-linking.

Marketed under the trade name Eponol 55, the new epoxy is only intended for use in lacquer-type systems. It is dissolved in a suitable solvent, and the coating is formed by solvent evaporation alone. Two Eponol solutions are commercially available; one contains methyl ethyl ketone solvent, the second uses Cellosolve acetate.

Epoxy used in the new formulation is formed by the standard reaction of bisphenol-A and epichlorohydrin. But by developing a new process to grow long polymer chains, Shell has been able to get high performance out of the standard material, without the usual cross-linking via cleavage of the oxirane ring.

The search for "one-can" epoxy resin systems has also led to the development of Linde Co.'s catalyst-loaded molecular sieves (see p. 68). This differs from Shell's approach in that Linde uses a curing agent but is able through use of the sieves to keep it suspended in the can with the resin. Linde's material can be used in many more applications than Shell's Eponol, but is considerably more expensive. The sieves, which are used in 20-50% loadings by weight with resin, cost around $2/lb. Eponol systems cost around $50¢/lb.

Japanese firm develops shortcut in dimethyl terephthalate process

Japan's Kawasaki Chemical reports that it has achieved a shortcut in the Henkel route to dimethyl terephthalate (*Chementator*, Sept. 22, 1958, p. 69). With it the company plans to boost DMT production from 700 tons/mo. to 1,050 tons by next spring.

In the original terephthalic process, which Kawasaki licenses from Germany's Henkel & Co., potassium orthophthalate (derived from phthalic anhydride) is catalytically isomerized to the terephthalate. Treatment with acid liberates crude terephthalic acid (TA), and potassium hydroxide, which is recycled. The crude TA is purified, then esterified with methanol to form DMT—the starting material for polyester fibers and films.

Kawasaki says it can now add the methanol directly to the crude terephthalic production step, thus avoiding the need to isolate pure TA. Product from this reaction is now DMT plus the potassium salt recycle stream.

The firm has patents pending in Japan, Britain, the U. S. and West Germany, is therefore reluctant to spell out any details of its new reaction step.

Increasing interest in polyester fibers has led two more Japanese firms—Mitsui Petrochemical and Mitsubishi Chemical—to seek permission from Japan's Ministry of International Trade & Industry to license the conventional Henkel process. Commenting on this potential new source of competition, a Kawasaki spokesman claims that the process improvements will give his company a significant edge over the newcomers.

Rotating disks form the core of new water-distillation process

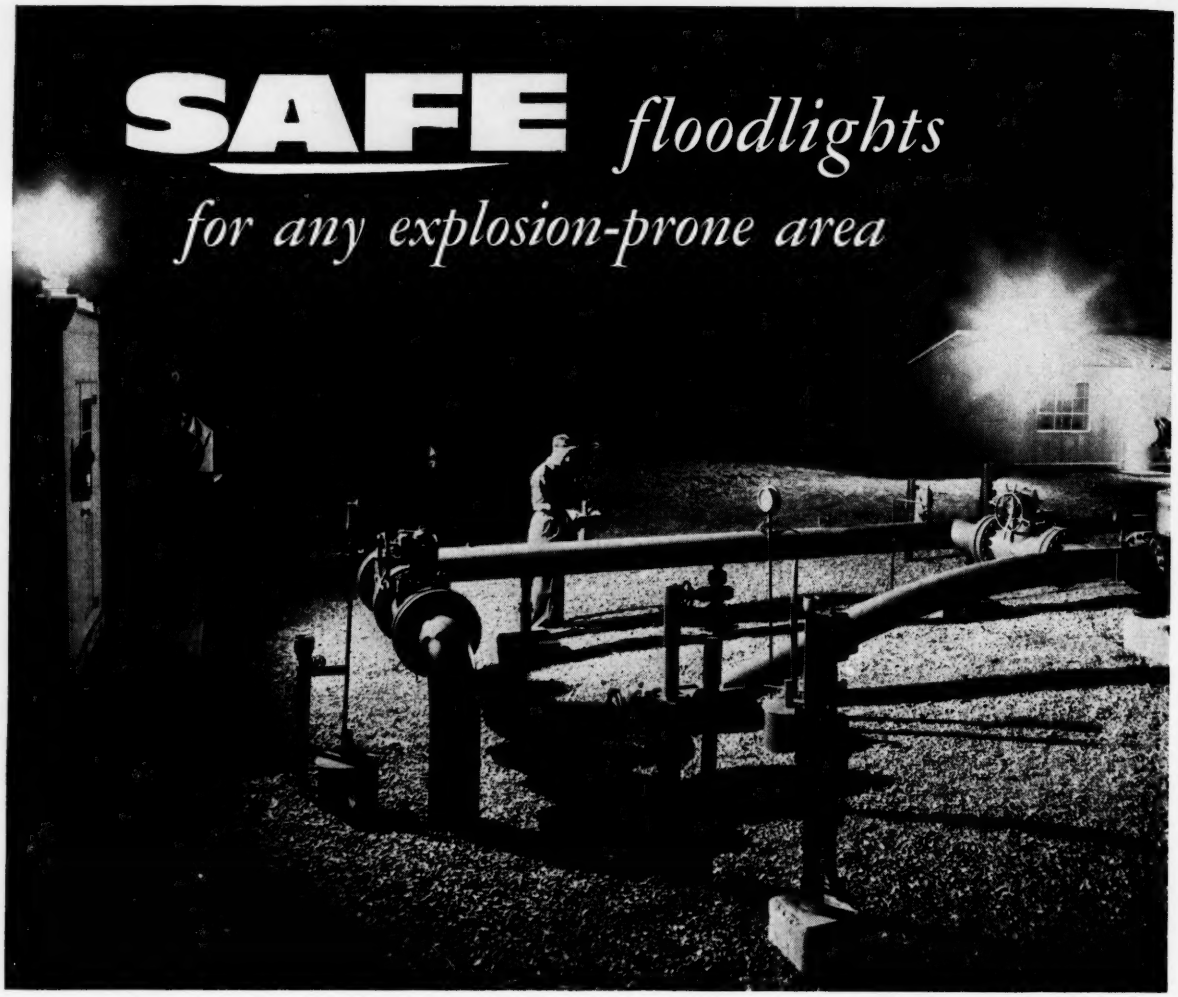
Diffusion-distillation is the name given by General Electric Co. to a new water-desalting method just announced.

Process employs a horizontal cylindrical chamber, containing a shaft on which disks are mounted. These rotating disks pick up hot, incoming water from the bottom of the chamber. The water then evaporates and diffuses to cool, stationary plates at the top of the cylinder. There, the vapor condenses and flows to a collecting trough.

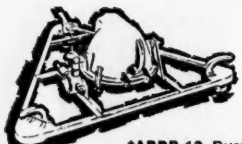
Incoming water is raised to about 200 F.

SAFE *floodlights*

for any explosion-prone area



These incandescent floodlights are explosion-proof and weather-proof . . . ideal for lighting hazardous areas such as this.



***ADDR-12.** Dust-ignition-proof floodlight. On aluminum dolly to fit over 33-inch manhole.

****RCDE-8.** Explosion-proof incandescent floodlight. Prisms treated to eliminate glare.

*****EVH.** Explosion-proof hand-lamp. Rain-tight, weather-resistant and easy to re-lamp.

What's your illuminating problem?

- Perhaps your problem is dust-ignition-proof floodlighting for dry, dusty, hazardous areas.*
- Possibly you're interested in explosion-proof incandescent floodlights for flush ceiling mounting — something that might be suitable for use in a process control room.**
- Maybe you're looking for rugged, explosion-proof hand lamps — for safe lighting of interiors of large fuel tanks during cleaning or painting operations.***

Whenever and wherever explosion-proof illumination is needed — whether in fluorescent, mercury vapor or incandescent lamps — Crouse-Hinds has a unit to fit your application need.

Check Catalog 320 for floodlights and Catalog 3000 for hand lamps. Or, see your Crouse-Hinds Distributor.

CROUSE-HINDS

REG. U.S. PAT. OFF.

MAIN OFFICE: SYRACUSE, N.Y. **FIELD OFFICES:** Albany, Atlanta, Baton Rouge, Birmingham, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Corpus Christi, Dallas, Denver, Detroit, Houston, Indianapolis, Kansas City, Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, Portland, Oregon, St. Louis, St. Paul, Salt Lake City, San Francisco, Seattle, Tampa, Tulsa, Washington. **RESIDENT REPRESENTATIVES:** Baltimore, Md., Meriden, Conn., Reading, Pa., Richmond, Va., Springfield, Mass. **FOREIGN AFFILIATES:** Crouse-Hinds Company of Canada, Ltd., Scarborough, Ont., Crouse-Hinds-Domex, S. A. de C. V. Mexico, D. F. **MANUFACTURING LICENSEE:** Peterco, Sao Paulo, Brazil

by circulating through the condenser plates, followed by heating in a small auxiliary heater to 210 F. The disk-shaft arrangement is the only major moving part, so no operator is required.

The unit operates near 1 atm. and in the presence of air. This allows simple design, but also means that high-throughput units would require an unwieldy amount of condenser area. GE feels the method is best suited for capacities up to about 1,000 gal./day, accordingly is aiming for sales to homes or small commercial establishments, for operation on hard, brackish or sea water.

According to GE, it appears that diffusion distillation will be competitive from a cost standpoint with conventional water-heater and water-softener combinations—neither of which can desalt water. A commercial unit could be operated by a 1/50-hp. motor, and with no greater total energy input than an ordinary hot-water heater.

Company hopes to have its first commercial units on the market about a year from now, then gain enough servicing experience to enter the home-appliance field a year later. The Office of Saline Water has also expressed interest in diffusion-distillation for certain civil defense and military applications.

First paint vehicle based upon an emulsion of linseed oil and water has been announced by Cargill, Inc., Minneapolis. This combination blends the convenience of water-thinning with the high quality of oil-based paint. One other combination paint, using a solution of linseed oil in water, was announced earlier (Chementator, May 29, p. 38).

Another styrene project will get ethyl benzene from "natural" sources

Superfractionation of ethyl benzene from mixed-xylene refinery streams, a route pioneered by Cosden Petroleum Corp., will furnish the feedstock for the latest announced styrene monomer project: a 75-million-lb./yr. unit at Baytown, Tex., to be built by Marbon Chemical Div. of Borg-Warner Corp.

Enjay Chemical Co. will supply the ethyl benzene by pipeline from parent Humble Oil's Baytown refinery. Besides the Cosden plant at Big Spring, Tex., the only other styrene plant to use "natural" feedstock is the new 70-million-lb./yr. Sinclair-Koppers plant at Houston. (Other styrene units use "synthetic" ethyl benzene made by alkylating benzene with ethylene.) However, as more refiners seek to upgrade refinery streams, others may also elect to tap ethyl benzene fractions for their chemical value.

The new Sinclair-Koppers plant, built by Badger Mfg. Co., operates under a Cosden license covering superfractionation know-how. At Cosden's refinery, for example, it takes a 350-plate distillation train to separate 99% ethyl benzene from a gasoline stream.

Since Humble doesn't have that kind of superfractionation unit at Baytown, observers believe the refinery's ethyl benzene product may require additional purification before dehydrogenation. However, according to Marbon's president, Robert Shattuck, no licensing agreement has yet been concluded with Cosden since process design has not yet been fixed, nor has a contractor been selected.

Present plans call for construction on the Marbon plant to start around the end of the year, with completion scheduled for early 1963.

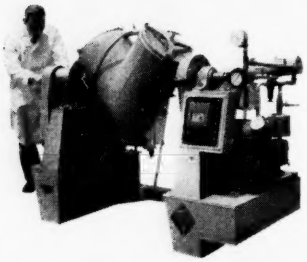
The proposal advanced by The Fluor Corp., Los Angeles, has been accepted by the Atomic Energy Commission as basis for contract negotiations for the $40-million Advanced Test Reactor to be built at Idaho Falls, Ida.

Coal-slurry burning demonstration ups coal's East Coast prospects

A major step forward in utilization of coal, and a potential strengthening of coal's position as a fuel in the Eastern utility market, was demonstrated this month when a slurry, representative of material to be pipelined from the Pennsylvania coal fields, was burned directly in a steam boiler without auxiliary fuel. Previously, coal slurry had to be dewatered and dried before it was burned. Now it can be handled as a liquid, up to the time of combustion.

Transportation of coal slurry has been proved feasible by Consolidation Coal Co.'s (Consol) 108-mi. line from Cadiz to Cleveland, Ohio, which has transported over 5 million tons of coal since startup four years ago. Consol

(Continued on page 48)



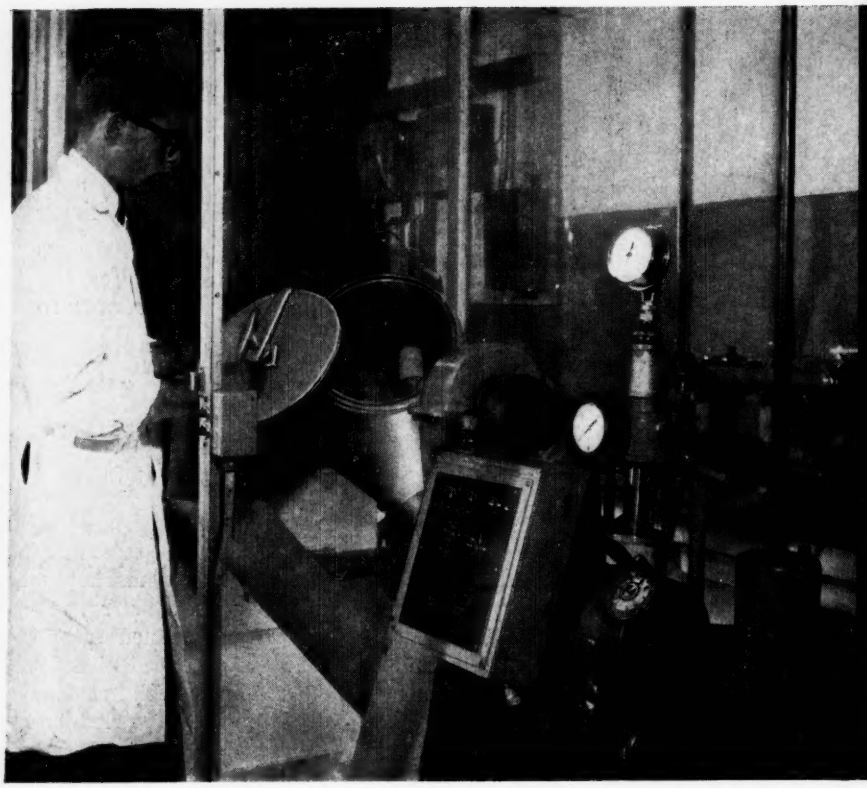
P-K SOLIDS PROCESSOR* SIMPLIFIES WESTINGHOUSE LAMP-MAKING OPERATIONS

Eliminates outmoded mixing, oven and screening steps • Reduces materials handling • Improves thoria quality

A ten cu. ft. P-K Solids Processor has consolidated a multi-step processing operation into a single unit operation – and improved product quality – for the Westinghouse Lamp Division, Bloomfield, N. J.

The pre-packaged unit blends, disperses liquids, and vacuum dries in simple sequence in the production of thoria, a material which adds strength and toughness to the tungsten wire used as lamp filament. Outmoded mixing, tray drying and screening

*patented



IN R & D — A one cu. ft. model is used in the development of experimental materials. Unit, purchased as a result of a pre-test at P-K's Pre-Test Laboratory, was used to work out thoria process now in use. Its unique flexibility, drying range plus accurate instrumentation in a complete package, make it an ideal research tool.

IN PRODUCTION — First, unit preblends 400 kilograms tungsten oxide for five minutes. Then, a thorium nitrate solution (10% of total charge) is added. Full vacuum is pulled and steam-heated jacket dries material in five hours.

PACKAGED P-K SOLIDS PROCESSOR performs up to 10 operations in simple sequence and in combinations:

1. Precision gentle blending. 2. Intensive blending. 3. Liquid-solids blending. 4. Granulation of solids. 5. Vacuum drying of solids. 6. Coating of solids. 7. Heat sterilization of solids. 8. Gas sterilization of solids. 9. Chemical reaction of solids. 10. Heating or cooling of solids.

Installation of totally packaged unit — including all wiring and instrumentation — requires only electric and water connections.

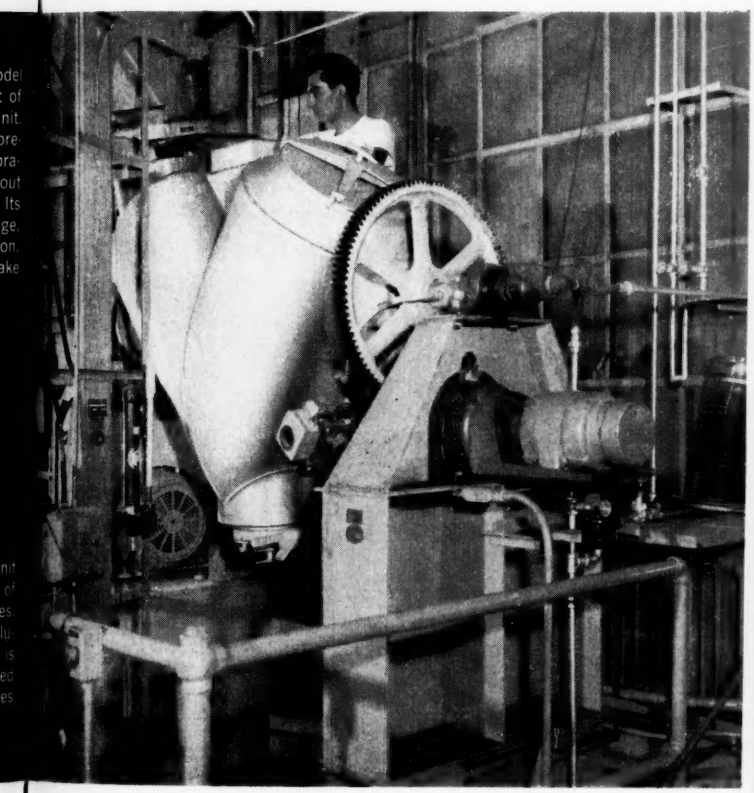
equipment previously used – and the accompanying materials handling steps – have been eliminated, and a critical toxic dust problem has been solved.

Moreover, according to Russell H. Atkinson, Manager of Lamps Parts Engineering, "Substantial quality improvement resulting in increased lamp life has been realized through the superior blending, liquid dispersion and drying of this three-in-one packaged Solids Processor."

PRE-TEST FACILITIES. Westinghouse pre-tested these economies. Why not explore the possibilities of simplifying your own solids processing operations at the P-K Pre-Test Laboratory. You'll find pilot models of standard, intensifier, and liquid-solids "Twin-Shell" blenders; packaged tumble dryers; ribbon and double-cone blenders; as well as the new Solids Processor.

Here, under your supervision, skilled engineers will test-blend your materials. They'll point out product improvements and process modernization . . . introduce you to new concepts in solids processing . . . predict potential economies in time, space, labor and equipment.

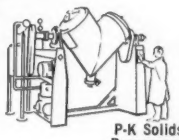
TO MAKE ARRANGEMENTS, write or phone George Sweitzer at Stroudsburg. Call direct by dialing 717–HAmilton 1-7500. He'll supply you with all the necessary information – dates, amount of material required, shipping and travel details.



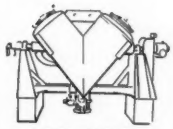
P-K PROCESSING EQUIPMENT

Laboratory Blenders.
1 qt. to 16 qts.
Available from stock in standard, intensifier and liquid-solids models.

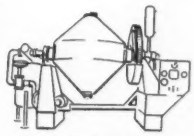
Standard Twin Shell Production Blenders.
1 cu. ft. to 4,000 cu. ft.



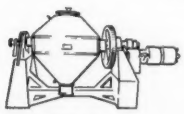
P-K Solids Processors.
1 cu. ft. to 50 cu. ft.



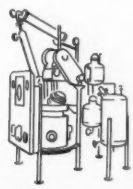
P-K Liquid-Solids Blenders.
1 cu. ft. to 50 cu. ft.



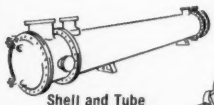
Packaged Vacuum Tumble Dryers.
1 cu. ft. to 300 cu. ft.



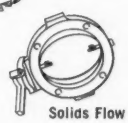
Standard Cone Blenders.
1 cu. ft. to 4,000 cu. ft.



Packaged Pilot Plants



Shell and Tube Heat Exchangers



Solids Flow Valve

REPORT ON SOLID-SOLID BLENDING. 23-page color article from Chemical Engineering discusses blending theory, practice, equipment and economies. Available upon request. Also ask for new P-K process equipment catalog No. 17-P. Heat Exchanger Manual No. 700-A, available upon company letterhead request.

Patterson Kelley

CHEMICAL AND PROCESS EQUIPMENT DIVISION
1211 BURSON STREET, EAST STROUDSBURG, PA.

now proposes to build a larger line, with up to 6-million-tons/yr. capacity, that could supply 20% of the East Coast market.

Research by Consol has shown that the 50-50 coal-water mixture designed for the Ohio line can be increased to 60% coal via proper particle-size distribution. Such a slurry, upon standing in a tank after transport through a pipe, stabilizes to form a 70-30 mixture that handles like thick cream. It was such a mixture that was burned in this month's demonstration at Jersey Central Power and Light Co.'s Werner generating station, in a cyclone burner designed by the Babcock & Wilcox Co.

Cost figures for the power generated by direct slurry burning indicate savings for the pipeline product, compared with rail-transported coal, despite a small loss of heat efficiency due to the slurry's water content. Stabilized slurry may also help coal to win back some of the ground that it has lost to oil and gas in the last five years. Coal's share of the Eastern energy market has fallen from more than 80% to below 70% in that period.

Additional emphasis will be given to basic research in engineering through establishment of an Engineering Section within the National Science Foundation. The new section, which replaces the Engineering Sciences Program office, will sponsor a wide variety of engineering research programs, with emphasis on areas of national need, such as fire research and transportation.

New Army report sees threat in latest Soviet fiber developments

Although the Soviet Union lags far behind the U. S. in development of synthetic fibers for consumer uses, it is developing three types of high-performance fibers that have no counterparts in this country. The new materials could be of value in defending against chemical, biological and radiological hazards, concludes a report just issued by the Army Quartermaster Corps.

The three Soviet fibers are: Enant (nylon-7), Ftorlon (a fluorine-containing copolymer), and Vinitron (a combination of nitrocellulose and polyvinyl chloride).

Enant's main virtue is said to be superior stress-strain properties at high temperatures and ultraviolet resistance. Ftorlon has better stress-strain characteristics than Teflon, says the report. Vinitron has a much higher softening point (around 300 F.) than ordinary PVC.

Of the three fibers, nylon-7 has probably received the most attention in this country, but the cost of the raw material (amino-enanthic acid) has dampened commercial interest. The acid can be synthesized by reaction of ethylene and carbon tetrachloride, followed by hydrolysis and amidation. If yields of enanthic acid were close to 100%, the material could be made for 20-22¢/lb. In practice, however, yields have been far below theoretical.

But researchers in both the Soviet Union and Israel have reported controlling the reactions so as to obtain products containing 85% enanthic acid. Yields on this order could pave the way for making of nylon-7 polymer for 30-35¢/lb., which would augur a big role in the synthetic-fiber market.

Copies of the report (PB 181 029) can be had for 75¢ from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C.

New gas to vie with acetylene and propane for flame cutting

The pre-eminence of acetylene and propane as industrial cutting gases is being challenged by a new entry in the field: methylacetylene that is stabilized with propadiene and propylene (MAPP). Developed and tested by the Dow Chemical Co., MAPP is said to be less toxic, safer, and 15-45% cheaper than the conventional fuels.

MAPP combines the high-energy characteristics of acetylene with the handling and safety features of propane. It can be liquefied and handled in regular LPG equipment, and performs well with standard torch tips, although for maximum efficiency, special tips may be installed on most regular torches.

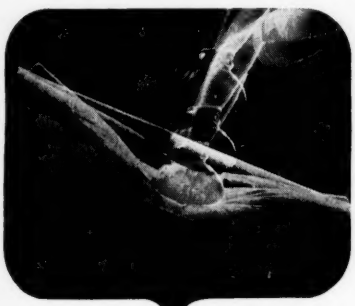
Among the advantages anticipated from brazing and cutting operations with MAPP are: reduced oxygen and fuel consumption, simpler handling and distribution facilities in the shop. The gas can be safely used at pressures to 300 psi. and at normal temperatures its vapor pressure is far below critical pressure. Thus, unlike acetylene, large cylinders of MAPP can be connected to a fuel-gas distribution system, with the gas piped under substantial pressures to points of use.

Dow says MAPP is suitable for all regular

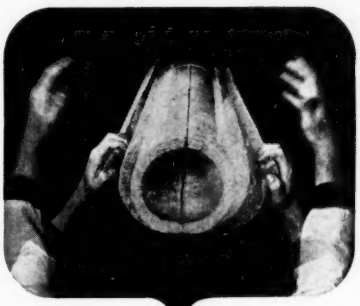
HERE'S WHY G-B SNAP*ON® GLASS FIBER PIPE INSULATION OUT-PERFORMS ALL OTHER PIPE COVERINGS

FOR CHILLED AND HEATED PIPE FROM SUB-ZERO TO 350° F.—INDOORS OR OUT— G-B SNAP*ON HAS NO SUPERIOR. AND HERE'S WHY:

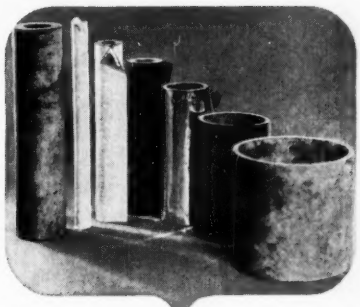
HIGH IN THERMAL EFFICIENCY. A heated pipe may keep this workman's coffee hot, but it's a cinch that he won't get a "hot seat" when he's protected by G-B Snap*On. The "K" factors of this all-glass-fiber insulation are second to none among all general purpose pipe insulations.



IMMUNE TO DAMAGE. Tough to beat and tough to abuse — that's G-B Snap*On. There's just no knocking out the highly resilient glass fibers that go into the construction of G-B Snap*On. Even when accidentally crushed or stepped on, it springs back to its original shape.



EASY, FAST TO INSTALL. Thanks to its snap-hinge action, G-B Snap*On slips over pipe and snaps back to its original cylindrical shape in one easy motion. Once in place, G-B Snap*On provides permanent insulation protection. It does not rot, corrode, mildew or otherwise deteriorate.



VARIETY OF SIZES. The only one-piece glass fiber pipe insulation available in sizes over 32" IPS, G-B Snap*On is also available in diameters down to copper tubing . . . varying thicknesses . . . plain or with a variety of factory-applied facings for use indoors or out.

WRITE FOR COMPLETE PRODUCT INFORMATION

GUSTIN-BACON *Manufacturing Company* GUSTIN gb® BACON

252 W. TENTH ST., KANSAS CITY, MO.

metal-cutting operations, including powder cutting of stainless steels, standard flame cutting of mild steel, metallizing, brazing and heating. Flame temperature is about the same as that of acetylene.

Another producer is swinging to the propylene-ammonia route to acrylonitrile. Britain's Imperial Chemical Industries is closing down its old acetylene-HCN acrylonitrile plant at Billingham, to convert it to the new process. Revamped unit, due on stream in a year, will have a capacity of about 10,000 tons/yr.

Chemical industry lifts operating rate, levels out investment

Preliminary capital spending plans of the chemical industry for 1962 show a 2% decline from outlays in 1961, according to McGraw-Hill's capital spending survey released this month. This reduction is in contrast to the all-manufacturing average, which shows spending will increase 7% in 1962.

However, petroleum companies plan to hike chemical spending by 11% to $289 million, so total chemical spending will remain constant.

Respondents to the survey, which include companies having 60% of the employment in the chemical industry, indicate capital outlays in chemicals will be $1.62 billion in 1962, compared with $1.65 billion in 1961. Planned spending in 1963 is now set at $1.57 billion. Despite these cutbacks from the near-record 1961 levels, the figures present a fairly steady spending plateau, nothing like the dip to $1.26 billion in 1958 that followed the $1.65-billion boom in 1957.

Most encouraging figure uncovered in the survey: chemical companies expect tonnage sales volume to increase 7% in 1962. Also, operating rate has risen to 79% of capacity, compared with 75% in December 1960. Preferred operating rate, however, is 93% of capacity. This spread between actual and desired operating rate is interpreted as the primary cause of the capital spending plateau. Excess capacity has caused downward pressure on prices, with consequent reductions in profits.

However, McGraw-Hill's economists note that price declines appear to be ending and that growth in demand for chemicals may be even greater than the anticipated 7%. Prospects are thus good for a highly profitable year, and actual capital spending may increase over the preliminary estimates when final 1962 plans are set.

Other areas of the chemical process industries all show significant increases in spending plans over 1961: nonferrous metals up 7%; pulp and paper up 6%; rubber up 11%; stone, clay and glass up 8%; petroleum and coal products up 10%.

Citric acid cleans and passivates steam boilers in short downtime

The time lost during boiler cleaning can be reduced by a new process that uses ammoniated citric acid as a cleaning fluid.

Developed by Chas. Pfizer & Co., the process removes both magnetite and copper deposits, and leaves a silvery-gray metal surface that resists subsequent rusting. The system has been successfully field-tested on both controlled- and natural-circulation boilers.

In operation, an ammoniated citric acid solution of about 3% concentration and pH 3-5 is circulated in the boiler at 200 F. Over a period of 4-8 hr., the temperature is allowed to fall to 150 F. as the iron oxide dissolves. A small additional amount of citric acid is then added to stabilize the iron before a 1% ammonia solution is added to raise the pH to about 10.

When the pH is decidedly alkaline, an oxidant such as sodium nitrite (0.25-0.50% of solution) is added, and agitation or circulation initiated and continued for 3-5 hr. The solution may cool below 150 F. during this operation in which copper contaminants are dissolved and stabilized in the form of a copper-ammonium complex. The unit is then drained, rinsed free of cleaning solvent and drained again.

If ammonia fumes and odors are objectionable, such as when circulation is achieved via a return tank, other amines may be used. Triethanolamine, for example, is nonvolatile, produces an alkaline solution, and forms stable complexes with iron and copper.

Since the cost of cleaning with citric acid is about comparable to other systems, according to Pfizer, the method's advantages are the savings in downtime and the boilers' resistance to re-rusting before being put back into service.

For More Industry & Economic News . . . p. 52

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Boron Fluoride, Complexes with Oxygen-Containing Compounds	DA-3469-OXY-1
Boron Trifluoride, Ether Complex, Tech.	DA-34711
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NEWEST COATING PROCESS: VACUUM ENCAPSULATION HANDLES WIDE RANGE OF PARTICLE SIZES

National Research Corp.'s technique enrobes solids in metals, inorganic and organic compounds to impart desirable properties. This operation complements several methods already employed for liquids.

The recent joint announcement by National Research Corp. and the Air Force that the former had been awarded a $250,000 contract to continue research and development on encapsulated ingredients for solid propellants focused attention on NRC's vacuum process.

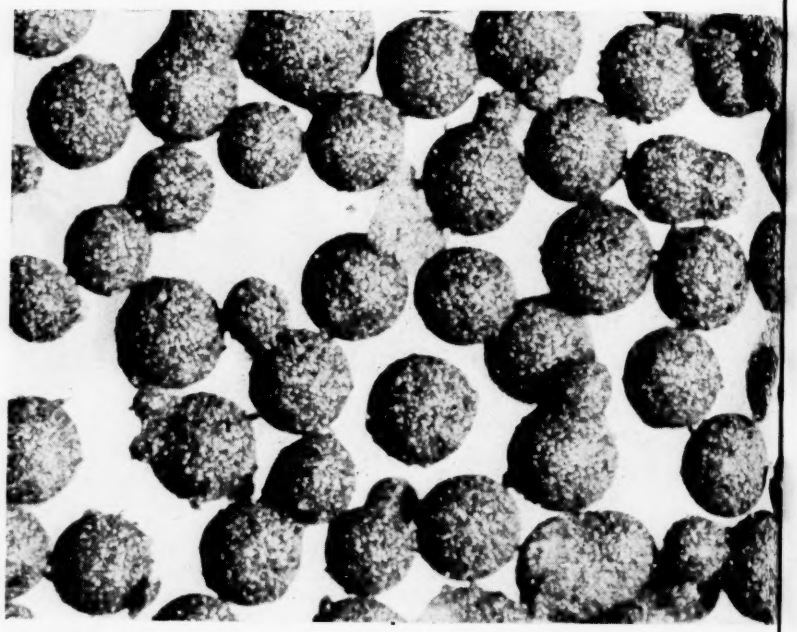
Resulting from more than five years of research, the new technique enables solid materials to be coated with metals, inorganic and organic compounds.

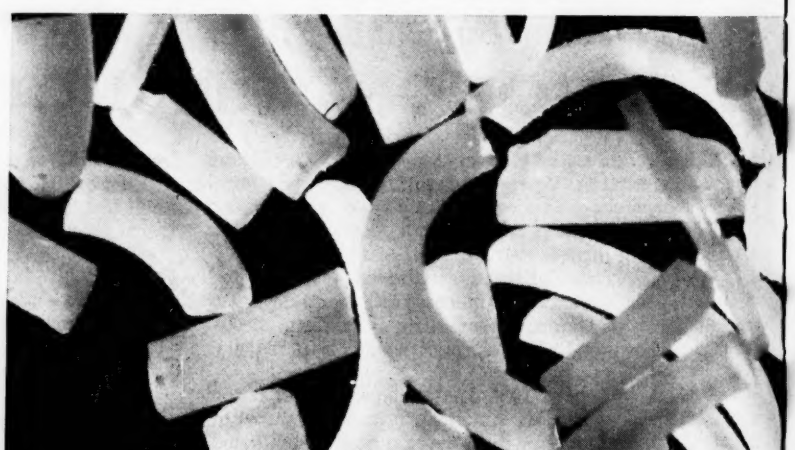
By use of a proper capsule, NRC has been able to:

- Impart specific optical, electrical and/or magnetic properties to a particle.
- Modify or control rates of solution, reaction, volatilization and/or adsorption.
- Alter surface tension.
- Increase shelf life of materials.
- Increase abrasion resistance.
- Improve handling and packaging characteristics.

▶ **First Time for Solids**—Because it encapsulates solids, the new system complements several other techniques developed for enclosing liquids. National Cash Register's "no carbon required" system, used in the manufacture of "one shot" office forms, comprises coating colorless lactones of various triphenylmethane dyes to form a milky-white emulsion. The emulsion is used to back-coat paper stock.

Southwest Research Institute has developed several encapsulating de-





Photomicrographs of encapsulated particles. Top: Polystyrene spheres coated with black aluminum. Bottom: Citrus oils enclosed in corn syrup solids.

vices—one a gravity-feed apparatus; the other, a centrifugal unit. With these, many different kinds and shapes of capsules have been created.

An extremely simple system was developed by Sunkist Growers, Inc., Los Angeles (U.S. Patent 2,809,895) specifically to preserve the natural flavor of citrus oil.

Basically, it consists of emulsifying the citrus oil in a hot corn-syrup-solids solution and extruding the emulsion downward into an organic alcohol, which is a nonsolvent for the syrup.

Filaments of the syrup, produced by cooling during passage between extruder and alcohol bath, are broken into short rods by a sweep agitator in the bath. Essential oil not enclosed in the rods is dissolved by the alcohol and thus removed from the product, which is then rinsed, vacuum-dried and packaged.

▶**NRC's System**—Material (substrate) to be coated by the NRC technique is placed in a vacuum chamber. Here, the substrate is systematically fed from a storage container to a vibrating coating tray. Encapsulating material is evaporated from a heated source and condensed on particles of substrate. Coated particles are then collected in a receiving container and the vacuum system vented. The procedure has now been adapted to truly continuous operation.

Several parameters affect quality of the capsule. One is the high vacuum behavior of the substrate. This parameter may be defined as a combination of the substrate's vapor and decomposition pressures. During encapsulation, heat is transferred to the particle by radiation from the evaporation source and condensation of the evaporating material. NRC's process compensates for the temperature rise by cooling.

Many other parameters such as particle size and shape, specific gravity, and chemical purity must be considered when planning an operation. If a maximum coating thickness with a minimum of material is required, spherical particles are more desirable than irregular ones because the sphere has the smallest surface-area-to-volume ratio. Conversely, larger quantities of coating material are needed on microcrystalline particles. Also important is the proper distribution of substrate in the coating zone, as this affects uniformity of capsule thickness.

▶**Numerous Uses Seen**—The new process permits coating of a wide range of solids of any particle size, shape and density. Among materials that can be used as coatings are metals such as aluminum, magnesium, zinc, cadmium, chromium, nickel, tin, silver, gold and boron; inorganic compounds such as zinc sulfide, magnesium fluoride and silicon monoxide; organic compounds such as waxes and paraffins. Capsule thickness can be varied from 100 A. to several microns.—AVG

ENGINEERS CALL FOR GREATER UNITY

First inter-American conference on chemical engineering pointed up ChE's problems in the Americas, and drew up guidelines for hemispheric progress.

Over 200 chemical engineers and educators from 15 countries of the Western Hemisphere gathered in San Juan, Puerto Rico, Oct. 23-27, for the First Inter-American Congress of Chemical Engineering.

They discussed ways to promote the study, application and dissemination of chemical engineering science throughout the Americas. Main accomplishment was adoption at the final session of the following resolutions to:

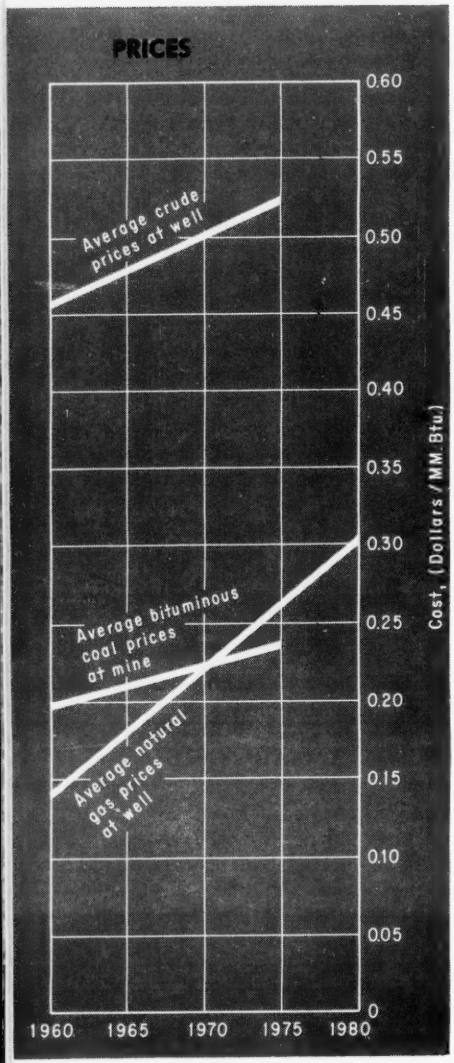
- Establish an Inter-American Society of Chemical Engineers.
- Hold a second congress in Peru and a third in Mexico, at dates to be decided later.
- Establish a Latin-American association of schools and faculties of engineering, and seek the support of the Organization of American States and the Alliance for Progress for this purpose.
- Form a commission of three countries to establish a standard Spanish-language nomenclature of chemical engineering.
- Contact private groups and government agencies of the various countries, and seek their support for the future congresses.
- Establish a commission to study how chemical engineering can be used to help the economic development of Latin America.
- Create an inter-American association to study, first, the teaching of chemical engineering, and then the other branches of engineering.

In a panel discussion concerned with the exchange of engineering information, the Latin-American participants pointed out that their biggest problem is coordination among themselves. Frequently, there is no common technical language among the Spanish-speaking countries, and technical people there have better communications with the U.S. (through publications and visits) than they do with their own neighbors. Another problem is the difficulty in publishing technical books in Latin America, where the author must do his own publishing.

There were nearly 90 papers presented at sessions ranging from sugar technology to chemical engineering education. The authors spoke in their native tongues and, in most cases, simultaneous translation was available. When not attending sessions, the delegates visited many processing plants on the island, as well as power stations and a water treatment plant.

The congress was sponsored by the College of Agriculture and Mechanic Arts of the University of Puerto Rico, the Institute of Engineers, Architects and Surveyors of Puerto Rico and the Institute of Chemical Engineers of Puerto Rico. Raphael Muñoz, president of the IChEPR. organization, was elected president of the congress at the first session. Dr. Muñoz and Ramon Guzman, secretary of the Institute of Chemical Engineers, were largely responsible for organizing the congress.

WHERE WILL COAL FIT INTO 1975's ENERGY PICTURE?



Further inroads by oil and natural gas are expected to reduce coal's share to about 24% of total energy demand. However, growth in total demand should boost coal usage.

Calling its estimate conservative, the U. S. Bureau of Mines recently forecast demand for coal at approximately 670 million tons in 1975. Framing this projection is a total energy demand of about 67,000 trillion Btu., equivalent to 2.6 billion tons of coal. This represents a 53% increase over today's total energy demand of 1.7 billion tons in coal equivalent.

In his analysis of the future breakdown of coal's energy end uses,* the bureau's T. Reed Scollon emphasized potential technical developments that were likely to alter the picture.

▶ **Electric Power**—The Bureau based its estimates in this area on the Federal Power Commission's expectations for a total electric power demand of 1,772 billion kwh. in 1975. Assuming that hydro power and nuclear energy will supply: (1) 15% of the requirements for 1975 electric power production; (2) a heat rate of 9,600 Btu./kwh.; (3) 24 million Btu./ton of coal; and (4) 73% of the conventional thermal power by coal, a total consumption of 440-million tons results. This exceeds current annual total coal production.

Development of the coal-burning gas turbine may greatly increase this figure. Electrification of railroads would also have a significant upward effect. However, developments such as nuclear fusion might reach the commercial stage and reduce use of bituminous coal.

▶ **Coke**—Approximately 90 million tons of coal will be needed for coke in 1975, assuming steel output will not exceed 150 million tons.

The estimate would be affected adversely by technological advances in direct reduction methods, in oxygen enrichment, humidification, higher blast temperatures, and the use of supplemental fuels. A new operating technique that may affect metallurgical coke consumption in the near future is the injection of supplemental fuels (gaseous, liquid, and pulverized solid fuel) into the blast furnace.

▶ **Manufacture and Mining**—In response to economic growth, population expansion and new construction, coal requirements for cement manufacture are expected to increase from the 8.2 million tons now consumed, to about 11 million tons. There also should be a relatively mild increase in coal consumption at steel and rolling mills, from the present 7.3 million tons to about 8 million tons. This will reflect to some extent rising demand for steel.

The outlook for coal in other segments of the industrial and manufacturing market, however, is less optimistic. The growing use of residual oil in industrial fuel markets (process heat and steam), of distillate oils in industrial space-heating, and of natural gas in both

* "Coal Supply and Demand in the Nation's Expanding Energy Market," by T. R. Scollon, chief, division of bituminous coal, U. S. Bureau of Mines, before the Southern Research Institute, Birmingham, Ala., Oct. 3, 1961.

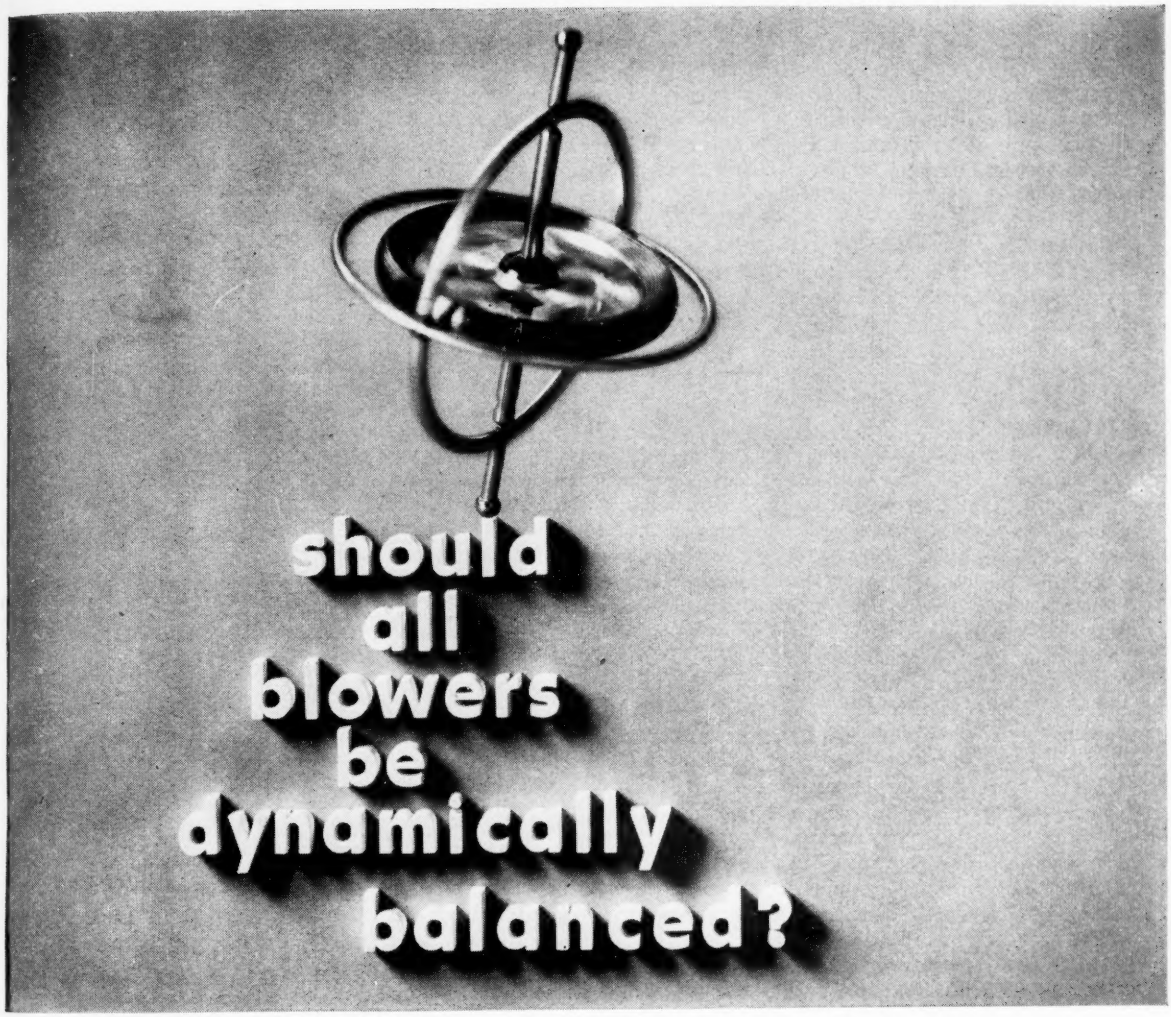
Source: W. E. Hopkins, Stone & Webster Engineering Corp.

MARKET

(Million tons, 1975)

Electric-power generation	440
Coke	90
Manufacturing and mining:	
Cement mills	11
Steel and rolling mills	8
Other mfg. and mining	70
Retail deliveries	20
Motive power	2
Exports	30
Total	671

Source: U. S. Bureau of Mines



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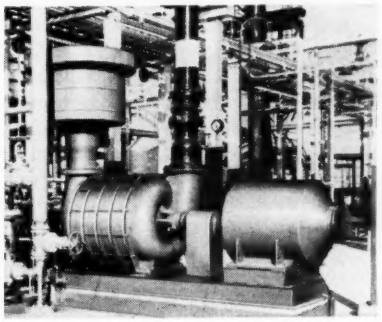

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of these applications, has been disastrous for coal. Consumption of bituminous coal declined from 124 million tons in 1947 to 76 million tons in 1960.

Nevertheless, these markets are especially sensitive to operational costs, and convenience is not as decisive a factor as in the residential and commercial markets. According to Scollon, the Bureau believes the rate of decline will reach its bottom within the next decade and will be followed by at least a modest gain for coal. Therefore, coal consumption in the industrial fuel and space-heating categories should approximate 70 million tons, compared with 76 million tons.

▶ **Motive Power**—With coal consumption by railroads already reduced primarily to such uses as station heating and other miscellaneous purposes, further losses probably will be inconsequential. Considering these outlets, together with what remains of the bunkering market, direct coal consumption for motive power in 1975 may approximate 2 million tons, compared with present 3-million-ton consumption.

▶ **Exports**—The past decade has seen U.S. exports of coal rise and fall with the interplay of international energy considerations, from a peak of 81 million tons in 1957 to less than half as much at present. In a manner reminiscent of our own experience, coal is being displaced abroad by oil and natural gas. Below is a comparison of the shares alloted to various energy sources in 1950 and 1959 in the total energy consumption picture for Western Europe:

	1950	1959
Coal	80.3%	59.6%
Crude oil	9.9	26.6
Natural gas	0.2	1.6
Other	9.6	12.2
	100.0%	100.0%

Notwithstanding the declining trend in exports, the worldwide demand for exceptionally high-grade U.S. coals, particularly those of metallurgical quality, has been firmly established, both for use in coke manufacture and for other purposes. Further losses in the Canadian and European market should be at least partly offset by increases in demand for U.S. coals in South America and Asia. The Bureau anticipates that by 1975 this market will stabilize at about 30 million tons, compared to 38 million tons in 1960.

▶ **Prices**—In a recent paper† on "Transportation of Electrical Energy vs. Transportation of Fuel," W. E. Hopkins of Stone & Webster Engineering Corp. pointed out that technological improvements in mining equipment and methods have nearly doubled the average output per man in the last decade. Mechanized underground and strip-mining techniques require less than half the average man-hours per ton of coal produced. Although these factors will have less of an effect on average prices in the future, the outlook for minimum future mine price increases is generally considered to be favorable.

As for railroads, regulated transportation rates normally form a considerable portion of total delivered coal costs. Existing competitive influences have forced management and the regulating agencies toward revision of arbitrary rate schedules.

Larger bulk shipments possible with barge delivery reduce unit costs considerably, but approximately 75% is shipped by rail due to limitations imposed by source or consumer location. The railroads are giving consideration to larger bulk hauling trains to reduce costs. Although changes may be limited to special situations, the evidence suggests determined efforts to compete with other forms of transportation. Despite these efforts, however, nominal increases in rail transportation costs are to be expected over an extended period.

Hopkins concluded that natural abundance, technological production improvements and transportation facility competition would limit future price increases of delivered bituminous coal, continuing its dominance as the main thermal power-generating fuel.—FA.

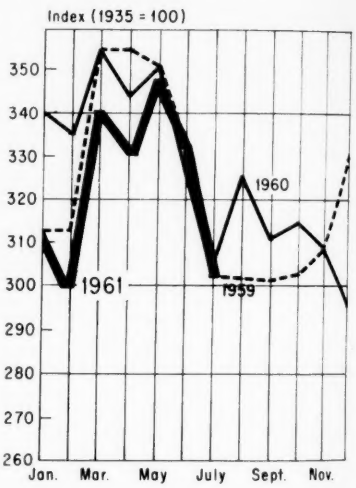
† Presented at the ASME-AIEE National Power Conference, San Francisco, Sept. 1961.

Chilton Elected by AACE

The American Assn. of Cost Engineers has elected Cecil H. Chilton, editor-in-chief of CHEMICAL ENGINEERING, as its president for 1962. Chilton is also editor of the recently published book, "Cost Engineering in the Process Industries."

Other officers elected by AACE are: D. I. Meikle of Meissner Engineers as vice president; W. J. Dodge, Socony Mobil Oil, treasurer; T. C. Ponder of *Petroleum Refiner*, secretary.

New members of the board of directors are: H. J. DeLamater of Industrial Estimating Service, and W. I. McKay of Fluor Corp.



Chemical Consumption Index

	May (Final)	June (Final)	July (Final)
Coal products	7.8	7.7	8.1
Explosives	12.6	12.0	11.6
Fertilizer	82.4	65.6	52.6
Glass	30.4	32.5	31.3
Iron & steel	16.5	15.7	14.8
Leather	4.3	4.4	4.3
Paint & varnish	40.8	43.2	37.3
Pet. refining	32.3	31.3	33.2
Plastics	36.8	37.2	32.2
Pulp & paper	43.4	40.6	39.1
Rayon	24.3	24.5	24.1
Rubber	7.0	7.1	5.9
Textiles	10.3	9.7	7.9
Total	348.9	331.5	302.4

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			6' Long Tubes	9' Long Tubes	12' Long Tubes	14' Long Tubes	16' Long Tubes
90	6"	9	17.7	26.5	35.4	—	—
190	8"	19	37.3	55.9	74.5	87.0	99.5
310	10"	31	45.6*	91.2	121.6	141.9	162.2
420	14"	42	81.7	123.3	164.8	192	220
640	16"	64	124.3	187.7	251	293	335
850	18"	85	165.2	250	334	389	444
1090	20"	109	213	320	427	499	570
1350	22"	135	263	397	530	618	706
1630	24"	163	317	479	640	746	852
1950	26"	195	379	573	766	892	1017
2330	28"	233	453	684	914	1065	1217
2680	30"	268	521	786	1051	1225	1400
3490	34"	349	679	1024	1368	1595	1822
4390	38"	439	855	1289	1722	2009	2295
5960	42"	596	1162	1749	2336	2727	3118
6850	45"	685	1335	2010	2685	3135	3585

*This unit has 4½' long tubes.

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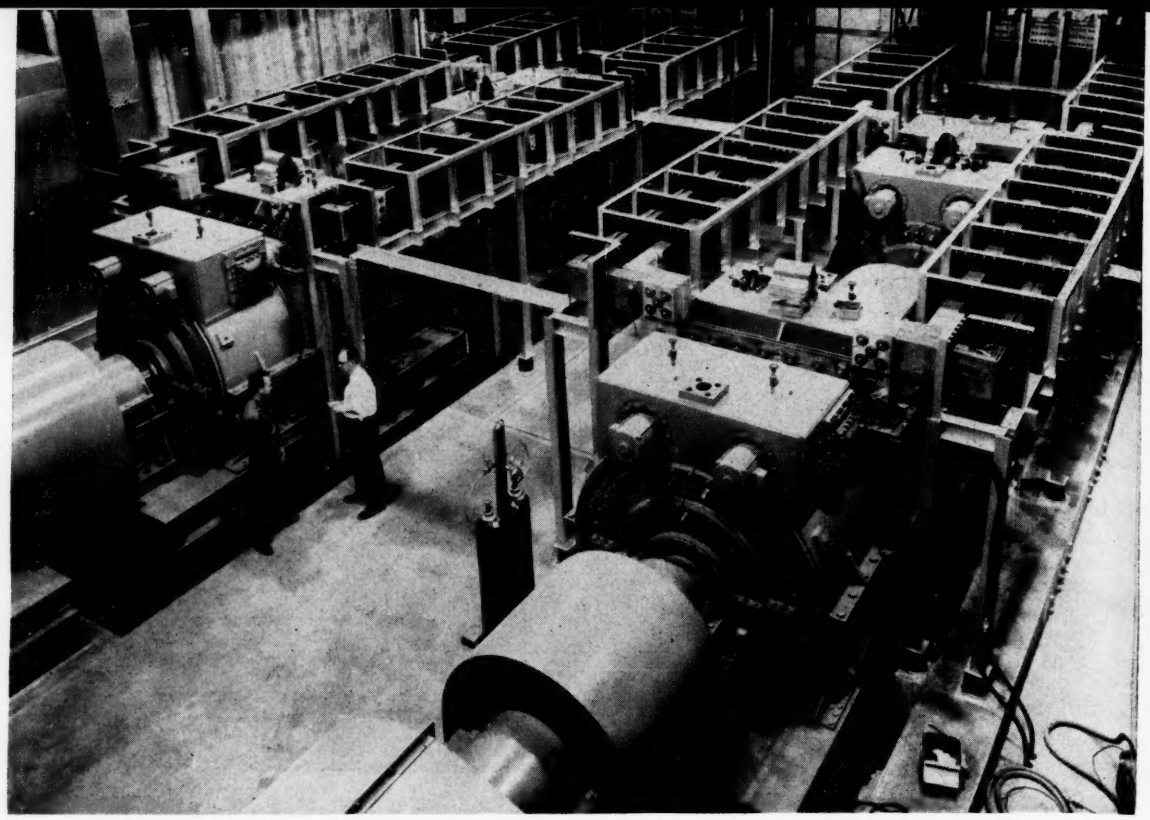


Four acyclic generators, rated at 550,000 amp. each, power an induction coil for an Air Force wind tunnel.

ACYCLIC UNIT GENERATES DIRECT CURRENT DIRECTLY

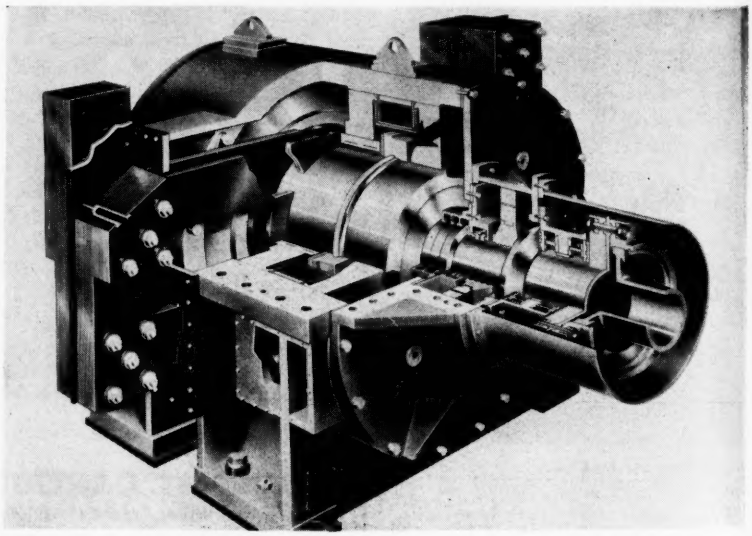
Aimed at the chlorine and aluminum industries, this generator uses liquid metal in the collector ring instead of sliding brushes.

A method for generating large blocks of d.c. power—without the use of sliding brushes or the necessity for rectification—is being offered by General Electric Co. for trial by the process industries. Called the acyclic generator, this machine is designed to produce extremely heavy direct current at low voltage under continuous operating conditions.

With such characteristics, the device has obvious potential in aluminum reduction and chlorine production—two large power-consuming fields whose production costs are linked closely to the availability of cheap d.c. power. And the potential is strengthened by GE's claim that installed cost is estimated to run 25% less than for installation of conventional generating and rectifying equipment.

GE is introducing the generator at a time when chlorine production is continuing a steady increase, with even greater growth forecast. Now more than 4.6 million tons/yr. (up from 3.4 million in 1955), output may double by 1971.

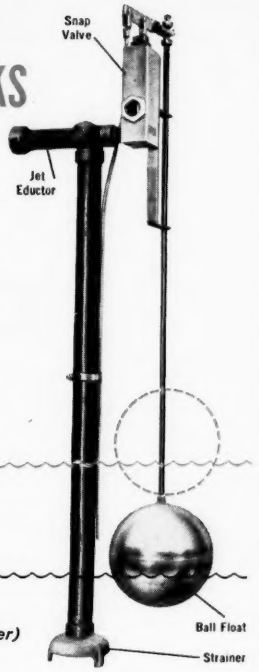
(Continued on p. 60)



Collector ring (arrow) uses liquid metal as conductor from generator.

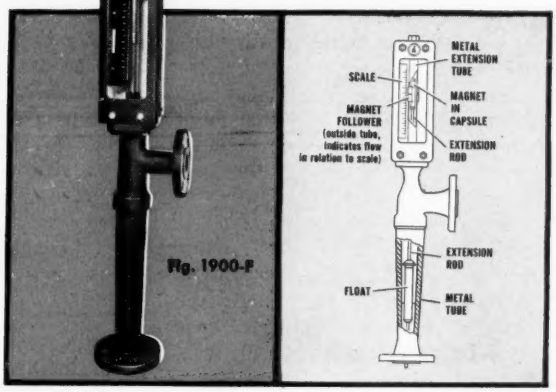
WATER-OPERATED SUMP PUMP WORKS AUTOMATICALLY

Ejector-type sump pump utilizes kinetic energy of water under pressure to evacuate liquids from sumps, tanks, pits. When liquid accumulates, ball float rises, opens snap valve to begin operation. When liquid level falls, float drops, closes valve and pumping stops. Steam-operated types also available. See below.



Ask for Bulletin 2M (water) or Bulletin 2A (steam)

Measure Rate-of-Flow of HARD-TO-HANDLE FLUIDS with this SK Metal-Tube Rotameter



SK Metal-Tube (Armored) Rotameters are designed for measuring the rate-of-flow of hazardous fluids, high pressure fluids, and steam. Their accuracy, sound design, and sturdy construction make these instruments easy to apply and easy to use in direct and remote indicating, recording and controlling installations.

For details—ask for Bulletin 19A.

IMMEDIATE NEED? *Get a condenser from stock!*

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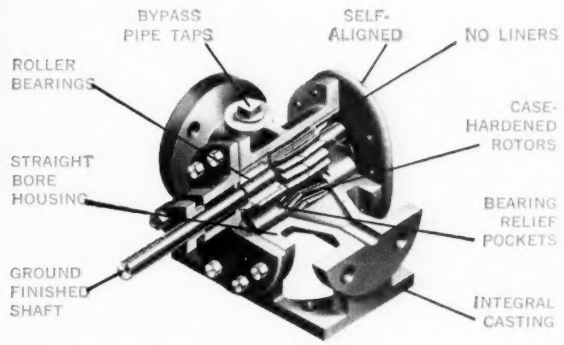
For details—ask for Bulletin 5AA.

SK Gear Pumps for DEPENDABLE PERFORMANCE

Most SK Gear Pumps are bought to solve "in-service" problems of performance or maintenance that were created by lower-cost competitive makes. Why not bypass this costly experimental phase by specifying quality-built SK Gear Pumps at the outset? Tell us about your application. We'll be glad to help.



For details—ask for Bulletin G-1.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
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▶ **Allis-Chalmers First**—The principle of the acyclic or unipolar generator is not new. Faraday discovered it over a century ago, but commercialization was almost nonexistent because of the high maintenance required on sliding brushes that picked up the current.

In 1958, Allis-Chalmers Mfg. Co. introduced a generator using liquid metal (sodium-potassium, NaK or "nack") to replace the brushes, and several machines were built for pulse or peak service, but not for continuous operation.

Today, GE's unit is offered for both intermittent and continuous service wherever the proper economic factors are present, i.e., where large amounts of d.c. power are needed and where low-cost fuel is available for either a steam or gas turbine installation to drive the generator.

The concept of the acyclic generator is interesting enough to cause observers in the chlorine and aluminum industries to watch keenly for the answer to the all-important question: Can the new machine perform day in and day out, in continuous operation, as dependably as existing d.c.-generating equipment?

Already proved in intermittent service, four of the generators are in operation at an Air Force wind tunnel installation, each providing 550,000 amp. at 45 v., to charge a giant induction coil. The arc discharge from the coil produces wind speeds up to 20 times the speed of sound.

Characteristics cited for GE's machine include:

- High continuous-current output.
- Efficiency of 98% or better.
- High peak-current capability.
- High-speed operation (3,600 rpm.).
- Uniform d.c. output, free of voltage ripple.

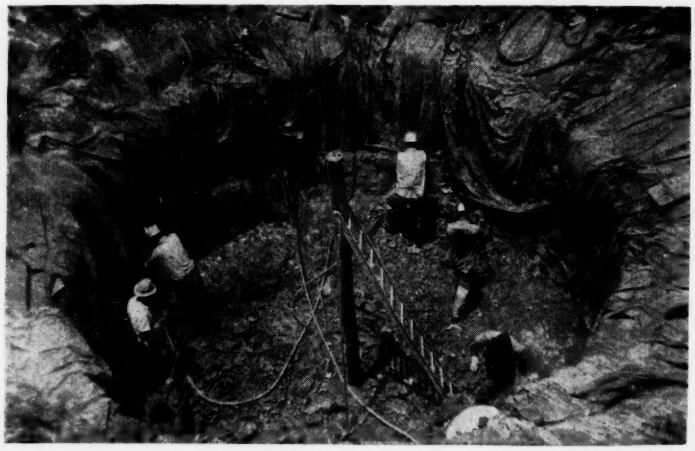
▶ **GE Has the "Nack"**—Heart of the new unit is the liquid-metal collecting system that replaces sliding brushes.

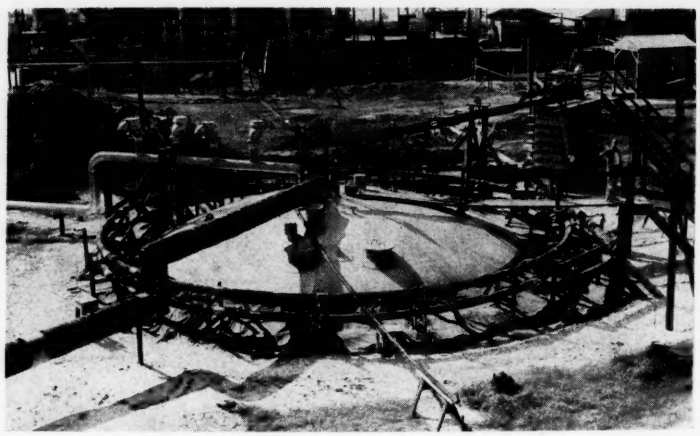
Upon startup, the machine is brought up to speed before the NaK is pumped into the collector ring. The liquid metal is contained in the raceway by centrifugal force, and must be drained before shutdown. During operation, NaK is circulated through an external cooling system.

NaK oxidizes rapidly in air and reacts with water, so the generator and cooling system must be enclosed and maintained under a slight pressure of pure, dry nitrogen.

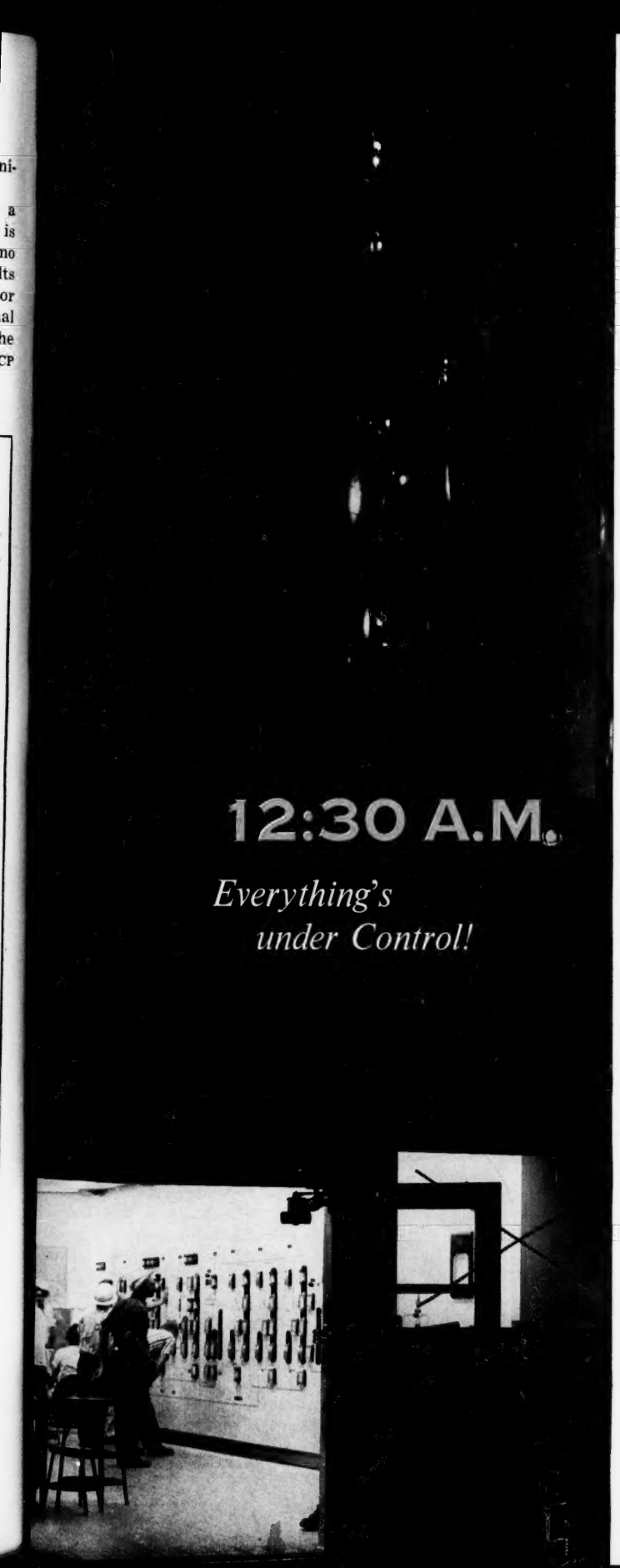
▶ **Design Detail**—Since it has a solid rotor, the acyclic generator is a single-turn machine—there is no way of changing the ratio of volts and amperes by changing turns or circuits. Voltage is proportional only to the peripheral speed of the rotor and total air-gap flux.—FCP

Company goes underground to store liquid methane





Details of the new underground storage technique developed by Conch International Methane, Ltd., and Constock-Pritchard Liquefaction Corp. (Chem. Eng., *Oct. 30, p. 45*) *are shown in the photos above. Refrigerant circulating through buried pipes first froze the earth in a ring shape that had an inner (unfrozen) diameter of 20 ft. This area was then scooped out to a depth of 20 ft. (top photo) and an aluminum roof fitted to the hole (below). After spraying the earthen walls with liquid methane to reduce thermal shock when filled, the 850-bbl. hole was ready for service. No lining is needed to prevent methane losses from seepage.*



12:30 A.M.

Everything's under Control!

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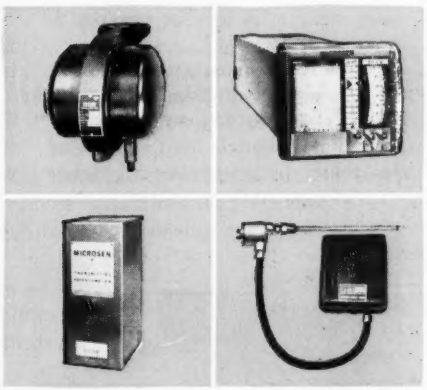
MICROSEN

All's right at half after midnight. The new shift settles in to monitor the processing steps. Meanwhile, out among the towers, Robertshaw-Microsen® Electronic Systems are providing maximum automation for data acquisition, transmission, recording and control of process variables. It's a typical job for Robertshaw—keeping everything under control. For greater system flexibility, lower initial investment and minimum operating costs—specify Robertshaw-Microsen for precision control of pressure, temperature, differential pressure, oxygen concentration, liquid level, gas analysis, pH, flow. Over 50 sales-service offices—write for address of the one nearest you—and for Technical Bulletin 10, entitled "Process Instrumentation."



Shown above: (Top, l. to r.) Microsen Transmitter, Microsen Recording Controller. (Bottom) Microsen Transmitting Potentiometer, Level-Tek Level Detection and Control System.

Robertshaw

Aeronautical and Instrument Division
Robertshaw-Fulton Controls Company,
Santa Ana Freeway at Euclid Avenue
Anaheim, California

ARE PNEUMATIC OR ELECTRONIC INSTRUMENTS BETTER?

Combined systems seem to have the edge over either all-pneumatic or all-electronic ones, although progress in electronic instrumentation is more likely in the future.

The lively controversy that periodically arises over the relative merits of pneumatic vs. electronic process control instruments has come back into the limelight, with both sides getting in their licks. Electronic units seem to have the better of it, though:

- Du Pont finds that repair frequency and repair time, as well as repair cost, are less for electronic instruments.
- Minneapolis-Honeywell Regulator Co. estimates that in many cases electronics may be cheaper to install.
- The Instrumentation Advisory Committee of the Assn. of British Chemical Manufacturers (ABCM) finds that although the first cost of electronic instruments is higher than for the equivalent pneumatic equipment, installed cost will be less, and maintenance should be simpler and cheaper.

On the other hand:

- Imperial Oil Ltd., operating two near-similar facilities with both kinds of instruments, reports that the electronic units cost more to install and required a little more maintenance.

▶ **Comparable Processes**—The Du Pont experience, as related in the McGraw-Hill publication *Control Engineering*, was compiled from maintenance records for upkeep of the two types of instruments used on the same process. Instruments of both systems were maintained by the same crew of mechanics under the same foreman, and factors like plugging, freezing, and corrosion affected the two systems equally.

From carefully kept records, the following performance characteristics were obtained:

Electronic rated over pneumatic on repair frequency and repair time. Frequency, jobs/instrument was 1.41 vs. 1.58, and time, in man-hour/instrument was 2.66 vs. 2.80.

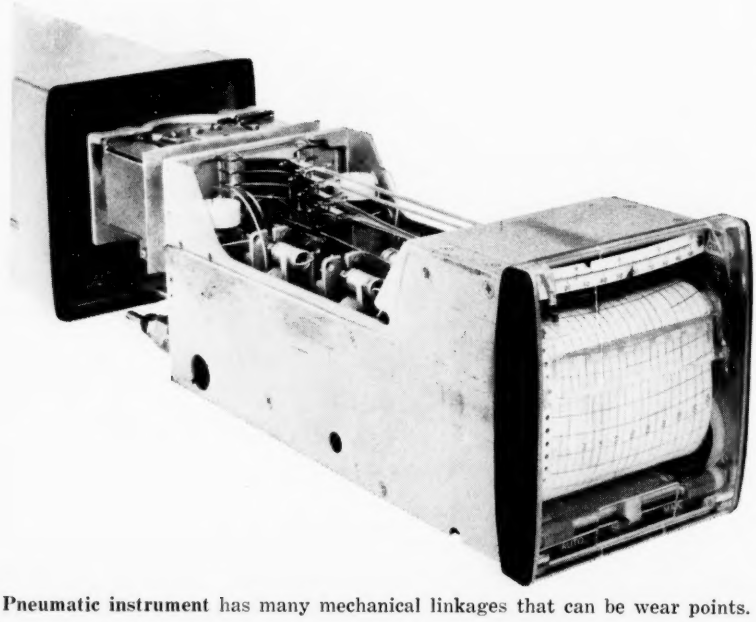
Electronic unit has few moving parts.

When all labor and material costs were consolidated on an annual repair bill basis, the electronic system moved well out in front—only $6.30/instrument compared with $9.80. The cost of labor was only slightly lower, but materials for repair were considerably cheaper, because the electronic parts are generally standard radio components that are inexpensively mass-produced, while the pneumatics are usually made up of low-production mechanical subassemblies.

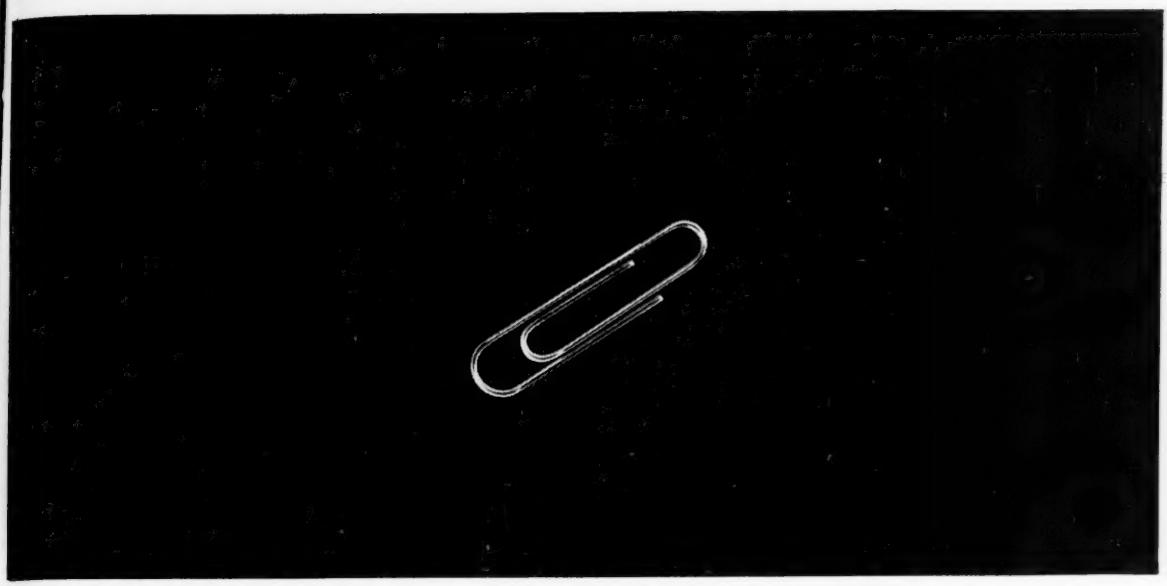
For a final evaluation, mechanics who serviced the instruments were polled as to their preferences. The results, (see tabulation, p. 64) show a clear-cut advantage for electronic instruments by a margin of almost 4 to 1. Reasons most often given were:

- Easier to calibrate.
- Easier to repair because of plug-in construction.
- Better control of the process.

▶ **Another Vote for Electronics**—At the Instrument Society of America's September meeting in Los An-



Pneumatic instrument has many mechanical linkages that can be wear points.



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Mechanics' Preference . . . Electronics, 4:1

	Electronic (Percent)	Pneumatic (Percent)	Undecided (Percent)
Easiest to calibrate	86	0	14
Easiest to troubleshoot	52	17	31
Best control of process	48	10	42
Best diff. pressure transmitter	73	13	14
Best pressure transmitter	74	11	15
Best temperature transmitter	31	36	33
Best controller	58	9	23
Best transmission	62	14	24
Holds calibration best	38	21	41
Easiest to learn	55	21	24
Average	**60**	**16**	**24**

geles, Jack T. Teed of Minneapolis-Honeywell presented estimated costs for installing miniature electronic and pneumatic instruments on a methyl ethyl ketone production unit. Selection of the process was based on availability of data that permitted a realistic comparison.

Since the purpose of the evaluation was to show the difference in total costs rather than the actual total, certain costs common to both methods were eliminated, such as mounting and connecting transmitters to the process, and assuming that valves for both systems were pneumatically operated.

On this basis, which included 134 field-mounted transmitters and 122 control valves, the electronic installation cost $18,678 and the pneumatic one $35,782. The difference was largely due to the expense of the multiline bundles of copper tubing—which amounted to almost ⅔ the cost of the pneumatic installation.

While warning against carrying these figures directly over into other processes, Teed pointed out that in many cases it is felt that electronic instruments can be installed for the same money or cheaper than pneumatics, but that each case would have to be considered independently. Long distances between control points seem to favor electronic systems.

▶ **Overseas Report**—E. I. Lowe, chairman of the Instrumentation Advisory Committee of the ABCM, is reported in *British Chemical Engineering* as favoring electronic systems for large instrument installations.

He expressed this viewpoint after visiting a new refinery at Rotterdam that is equipped with latest electronic measurement and control instruments. The refinery covers a large area, and design of the control system—which includes one loop of 1,500 ft.—is said to have been greatly simplified by use of electronic instruments.

Elimination of expensive runs of air lines, and freedom from water accumulation and freezing, are two factors put forward by Lowe in support of his preference.

▶ **One Negative Vote**—Speaking in defense of pneumatic instruments at the ISA conference, S. Gordon Fogg of Imperial Oil Ltd., Winnipeg, Manitoba, detailed his company's experience with two similar refinery processes that were instrumented separately to permit evaluation of the two types.

Fogg reported on comparisons in each of six areas of service. Here are his findings:

Temperature Control—Electronic equipment gets the edge because it is simpler and requires less maintenance. In this case, the electronics possess an inherent advantage because the process variable is sensed by a voltage-producing device, and no conversion is necessary. Voltage-to-pneumatic conversion requires intermediate facilities.

Flow Control—The two systems are comparable, except that local indicators on the electronic system required more maintenance and frequently caused process upsets.

Pressure Control—Basic systems are comparable, with little to choose between them. But the electronic transmitter package can suffer to a greater extent should a ruptured bourdon tube flood the case with process liquid.

In the secondary area of pressure control, inexpensive local pneumatic controllers, mounted right on the control valve, are effective and trouble-free. In an electronic system where no instrument air is available, mechanically operated secondary controllers require more maintenance.

Level Control—Again the basic systems are comparable; but more maintenance was required on the electronic system. Further, the fast response of the electronic instruments—particularly to local vibration—resulted in over-frequent operation of the control system. The inherent lag in pneumatic transmission systems effectively smooths out response to vibrations before they are felt at the controller.

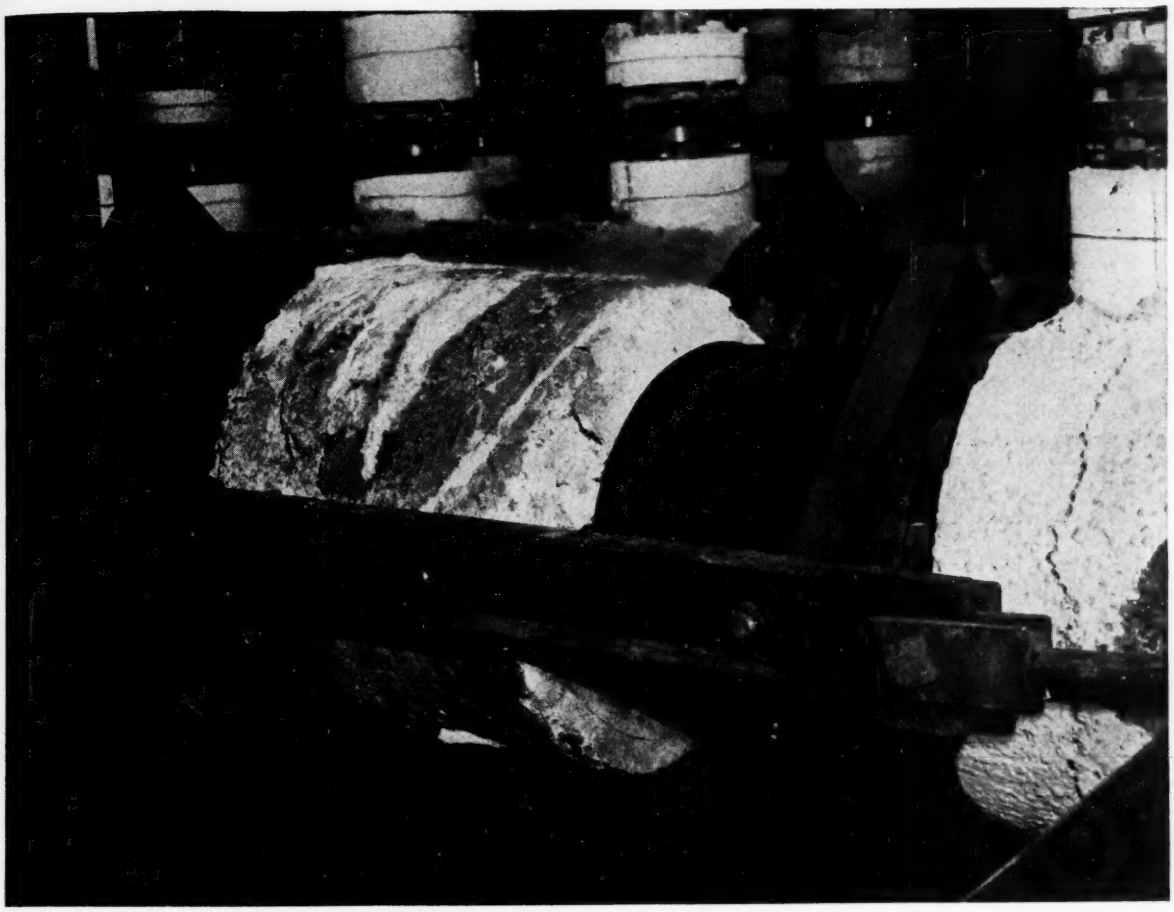
Control Valve — Pneumatics scored a clean sweep here, since the complexity of the other units resulted in frequent maintenance calls. When working properly, however, the electro-hydraulic operator outperformed the pneumatic devices.

Transmission System — Electronics are favored in this area because of the long life and inherent trouble-free operation of a properly designed and installed system of thermoplastic-insulated wire in conduit.

In summary, Fogg finds that the all-electronic system costs more to install and slightly more to maintain.

▶ **Current Status**—Despite the divergence of opinion represented above, it seems clear that where instrument air is available—and most chemical process plants have air compressers—a combination of the two types of instrument is probably the most effective means of controlling a process.

As Gordon Fogg put it, "Electronic systems are presently good enough to make a choice difficult. And while the best of pneumatic systems are probably available now, electronics are still comparatively new and will probably undergo rapid and progressive development."—FCP



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This is just one more example of customer confidence created by Zallea performance . . . the kind of performance you can expect when Zallea design and application specialists sit down with your engineers to tackle a tough expansion joint problem.

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WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

Processes

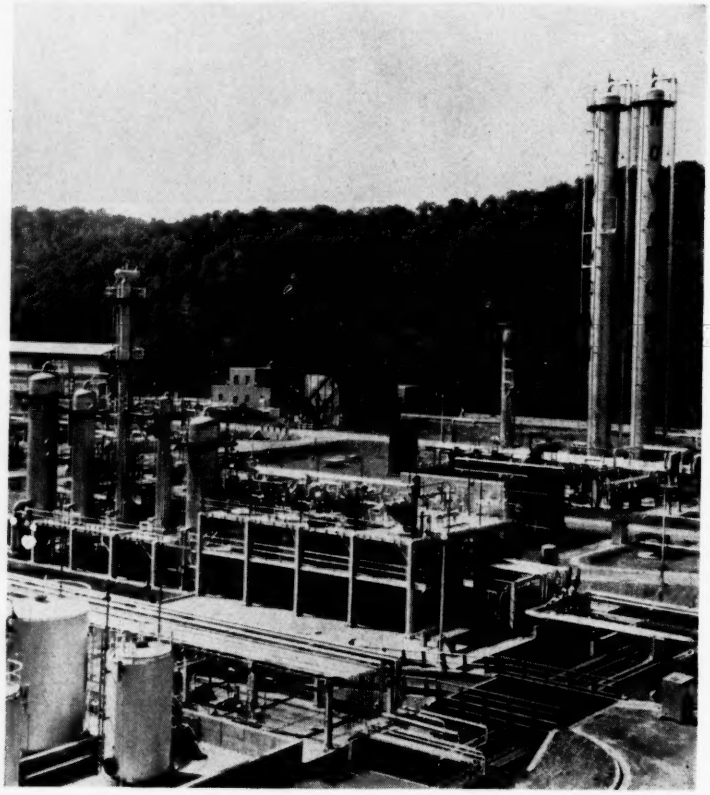
Thermal shock treating method for milk sterilization has been developed in Stockholm at Swedish University's College of Dairy Engineering, in collaboration with AB Separator Co. In the process, milk is preheated, then is given a "shock treatment," by instant heating to 284 F. with jets of steam, finally is quickly chilled by evaporation in a vacuum chamber.

Milk produced by this process is claimed to be completely free from micro-organisms and thus can be stored for extended periods. Operational costs for the new system are said to be lower than for conventional pasteurization units.

Tungsten, in large, high-purity single crystals, is now being made by Westinghouse Electric Corp. New technique first involves producing bars of high-purity tungsten by an undisclosed method, then zone-refining the material in a vacuum of 10^{-5} mm. Hg by electron-beam melting.

Resulting single crystals are quite ductile, even at temperatures as low as −330 F. Tungsten ribbon 3 ft. long, 0.5 in. wide and 5 mils thick has been rolled from a single crystal. Wire as fine as 30 mils dia. has been drawn from the ductile metal.

Add 30 million lb./yr. to polypropylene capacity



Novamont Corp., a wholly owned U. S. subsidiary of Italy's Montecatini, has placed its 30-million-lb./yr. polypropylene plant on stream (above) at Neal, W. Va. Additional distillation columns and other facilities have been constructed to permit doubling the output on short notice. And next year, Novamont plans to add an adjacent, 12-million-lb./yr. unit to manufacture films from the isotactic polypropylene resin.

Plants

FMC Corp. plans to build a toluene diisocyanate (TDI) unit adjacent to its chlorine-caustic plant in South Charleston, W. Va. To produce an undisclosed amount of TDI (a chief constituent of polyurethane), the unit is scheduled to be in operation in late 1963; construction will start next spring. According to company officials, cost and capacity of the plant are still to be set, pending the outcome of a company decision on whether to carry out the project alone or to make it a partnership enterprise.

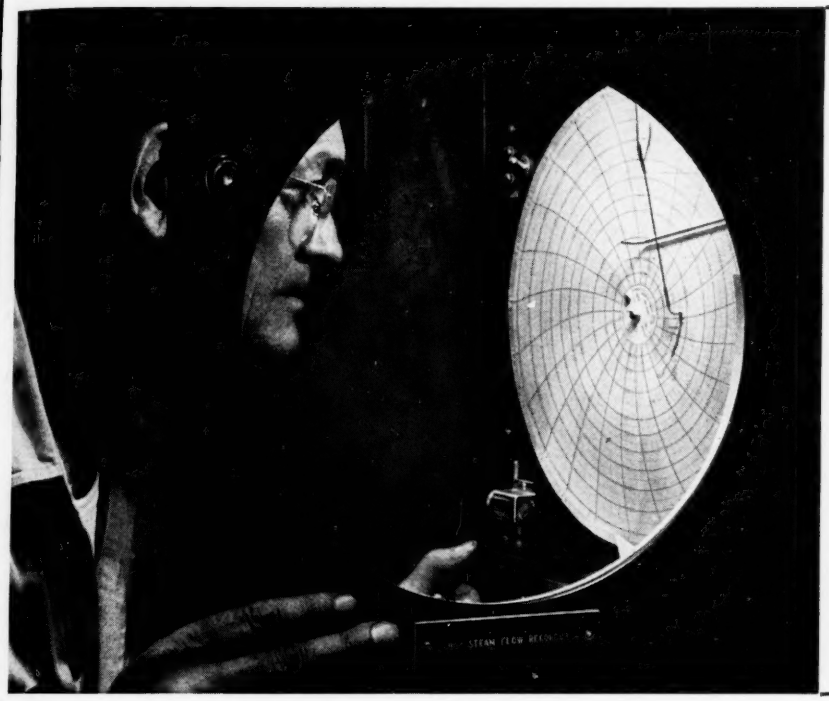
General Electric Co. has begun operating its Burlington, Vt., engineering center, devoted exclusively to developing ways of extracting fresh water from the sea. A project to obtain high heat-transfer coefficients for water evaporation and condensation via thin-film technology is already under way.

Henderson Sugar Refinery Inc. and the city of Mobile, Ala., have signed an agreement under the terms of which the company will refine all its sugar at a $12-million facility to be built by the city on Blakely Island in Mobile harbor. City will lease site from the Alabama state docks for $1/yr., sell revenue bonds to cover the cost of the project. Construction is expected to begin "soon."

National Starch and Chemical Corp. has picked Seadrift, Tex., for its upcoming $4-million, 45-million-lb./yr. vinyl acetate plant (*Chem. Eng.*, Apr. 4, p. 76). Acetylene raw material will be bought from Union Carbide Olefins Co., a division of Union Carbide Corp. Most of the vinyl acetate product

Turn to p. 152 for more CPI News Briefs

Which of these round chart recorder inking problems do you now have?



- ☐ **Clogged pens because of open-bucket systems**
- ☐ **Frequent refilling . . . resulting in excessive maintenance**
- ☐ **The mess of syringes and droppers**
- ☐ **Breakage of plastic bags and glass ink containers**
- ☐ **Flooding or starving at pen tip**

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Mark-Trol is a convenient conversion kit, enabling you to change over virtually any round chart recorder marking device in use today—in 10 minutes or less. Then your inking problems are over and done with.

Esterbrook knows that recorders don't operate in a vacuum, so they designed a marking device that does. From stylus tip to disposable ink cartridge, Mark-Trol is a completely sealed capillary system. You get a perfect chart record every time under any service condition, inside or out . . . humidity, precipitation, chemical fumes, dust, and in temperatures of from 0°F to 145°F. Contaminants are kept out, mess and mishaps are designed out. No clogging, flooding or starving. This faultless performance plus a generous ink supply in the cartridge mean that Mark-Trol operates up to 9 months without maintenance. And then the only servicing ever required is an occasional look through the window and replacement of the ink cartridge—and you do that in seconds.

Esterbrook has established a wholly new standard of reliability with Mark-Trol, and proved it in 2½ years of field tests in the power and processing fields.

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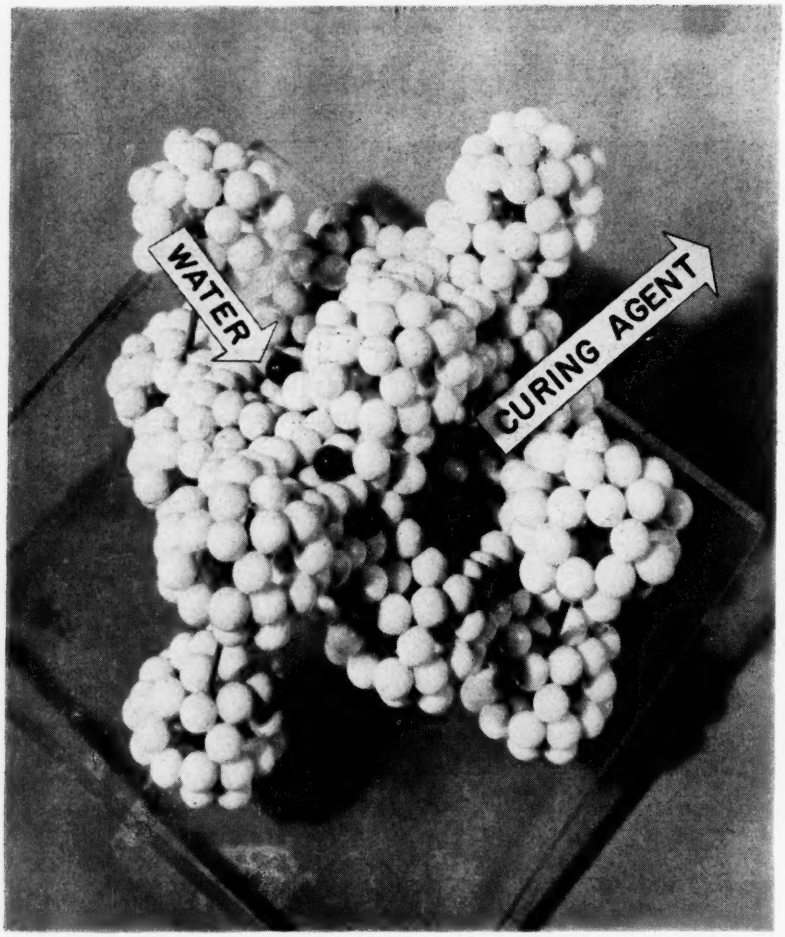
Please also send literature completely describing Mark-Trol. ☐



"LOADED" MOLECULAR SIEVES ARE KEY TO ONE-COMPONENT EPOXIES

Epoxy resins with a built-in, latent source of catalysts, have long shelf-life and reduce manufacturing costs of coatings, adhesives and potting compounds.

Latest approach in making stable, one-can epoxy systems that cure at room temperature consists in the adsorption of an epoxy catalyst or hardener in molecular sieves.

In this new method devised by Linde Co., the active hardener is completely isolated from the system because the larger molecules of epoxy resin cannot enter the sieve's pores. At the proper time, which can be several months after the loaded sieves have been dispersed in epoxy, the caged hardener can be released by heat or by a displacing agent.

Since molecular sieves will preferentially adsorb water molecules, even the moisture present in the atmosphere may act as the displacing agent.

▶ **Lower Exotherms**—Linde is now marketing Type 13X Molecular Sieves in three different forms that contain simple or modified polyamine hardeners, or tertiary amine catalysts.

When these hardeners or catalysts come out of the sieves into the epoxy system, they generate free hydrogen atoms that cleave the epoxy's oxirane ring and crosslink the resin. It is worth noting that the crosslinking of an epoxy resin during cure is a strongly exothermic reaction, particularly when a polyamine hardener is used. Temperatures of 400-500 F. can be reached in 1-lb. batches. But the heat of reaction, however, is much lower when the polyamine is added as a chemical-loaded molecular sieve. Thus, epoxy resins can now be safely used even for the encapsulation of delicate, temperature-sensitive electronic parts.

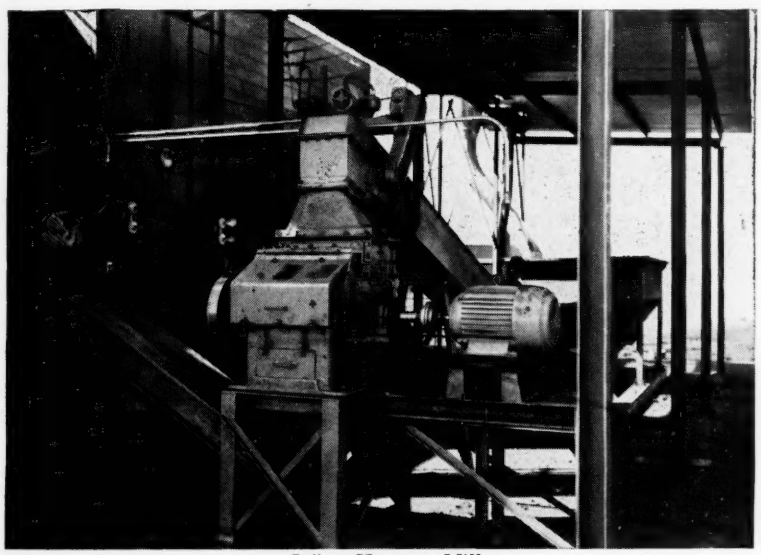
Previously, prolonging the shelf life of active epoxy hardeners hinged on lowering vapor pressure by increasing their molecular weight. Another approach was that of forming molecular complexes that would release the active hardeners when undergoing dissociation at high temperatures.

Both methods, however, are inherently limited because shelf life is lengthened at the expense of hardener reactivity; and the more the hardener is inactivated, the more difficult it is to obtain an adequate cure in an acceptable period of time and at a reasonable temperature. Also, these complexed catalysts will not produce a room-temperature cure.

▶ **One-Year Shelf Life**—By using chemical-loaded molecular sieves, Linde has formulated an epoxy coating that remains stable in the can for months (i.e., no increase in viscosity) and cures at room temperature in less than eight hours when cast as a 3-mil film and exposed to the atmosphere. The company has also reported curing an aged adhesive in 30 min. at 220 F.

In general, a simple polyamine-loaded molecular sieve will provide a one-year shelf life and cure at room temperature if a displacing agent such as water is present during cure. And tertiary amines, like triethylamine, can be released either thermally or by displacement, or both, as desired; the shelf

Jeffrey has a stake in your outdoor cooking



Jeffrey Hammer Mill

Jeffrey Grizzley Feeder

Dependable Jeffrey equipment is specified by major designer of charcoal briquetting plants

The trend toward outdoor living has increased the demand for charcoal briquets, caused a ten-fold increase in the number of briquetting plants in the last decade alone. The Aeroglide Corporation of Raleigh, North Carolina—the nation's leading designer and builder of charcoal briquetting plants—specifies Jeffrey Hammer Mills and Grizzley Feeders to assure 'round-the-clock production of clean, high-quality briquets.

Shown here is a typical Jeffrey Hammer Mill used to reduce charcoal to particles of consistent size prior to the mixing and binding operations. The Jeffrey Grizzley Feeder processes the finished briquets, screening out fine dust particles which are returned to the system. If you have a special materials handling problem, write today for complete information about Jeffrey's custom engineering services. The Jeffrey Manufacturing Company, 909 North Fourth St., Columbus 16, Ohio.

If it's conveyed, processed or mined, it's a job for Jeffrey.

JEFFREY

life of such a resin system will usually depend on the type of resin and hardener used.

Linde says that coatings, adhesives and potting compounds in the new one-can system can lower manufacturing costs because there is less labor involved with only one production line, and the packaging is greatly simplified. Waste caused by limited pot life or inaccuracy in mixing is eliminated, and even toxic polyamines can be safely adopted as curing agents.—**Linde Co., New York. 68A**

Insulation

New system can outlast glass-polyester laminates.

Recommended for applications up to 50 kv. at temperatures in the 155-180 C. range, Quinterrabord 880 consists of purified asbestos paper impregnated with an undisclosed polyester resin. Mechanically and electrically stronger than NEMA Grade A or AA laminates, this material can retain its dielectric strength when exposed to high temperature and humidity for long periods of time.

Produced in 35 x 72-in. sheets, Quinterrabord 880 comes in thicknesses of $\frac{1}{32}$ to $\frac{1}{2}$ in. It has a density of 110 lb./cu. ft., a perpendicular dielectric strength of 350 volt/mi. ($\frac{1}{8}$ in.), a tensile strength of 30,000 psi. It has twice the arc resistance of glass-polyester laminates and can support equipment weights without yielding.—**Johns-Manville Corp., New York. 70A**

Surfactant

Sterol-rich agent can yield stable emulsions.

Sterolan, as its name implies, is a lanolin derivative consisting of a complex mixture of high-molecular-weight sterols and related alcohols.

As a nonionic surfactant that is soluble in oil and dispersible in water, this product acts as emulsifier, emollient and penetrant in cosmetic and pharmaceutical preparations designed for local applications. Dermatologically innocuous, Sterolan is a good carrier particularly for emulsified cosmetics because it will absorb and retain many times its own weight of water.

The lanolin derivatives present in this surfactant can quicken emulsification by reducing tension at the water-oil interface of an emulsion. And although Sterolan is a water-in-oil emulsion, it will increase the stability of reverse systems. In such systems, it forms double interfacial films, one of which will extend more deeply in the water phase, the other more deeply in the oil phase.

Sold at 55¢/lb., Sterolan has been found satisfactory in experimental formulations of shampoos, hair sprays and various cleansing creams. — **Robinson-Wagner Co., Inc., Mamaroneck, N. Y. 70B**

Shrinkable polyolefin

Polypropylene film now reaches tensile strength of 27,000 psi.

A shrinkable polyolefin film, called Cryovac Y, is the latest polypropylene product that achieves higher strength by being stretched biaxially in an orientation process (*Chem. Eng.*, Apr. 17, p. 142). It has the highest tensile strength of any polyolefin film—a rating of 21,000-27,000 psi., or 5 to 6 times the strength of polyethylene.

The new film resembles cellophane in clearness, gloss and ease of handling in high-speed overwrapping equipment. And according to manufacturer's reports, Cryovac Y combines the lowest moisture transmission rate and the highest yield of any thermoplastic film used in packaging. Depending on gage, coatings and type of winding, its price per thousand square inches will range from 2 to 2.8¢.

Already approved by the Food and Drug Administration, this film can have hosts of packaging applications in other fields beside the food industry.—**Cryovac Div., W. R. Grace & Co., New York. 70C**

Silicone additives

Products can boost properties of urethane foam.

These flexible urethane sponges, made with new silicone additives, have a cell structure similar to

Newsworthy Chemicals

Page number is also reader service code number

One-component epoxies are based on molecular sieves.....68A
Asbestos insulation is impregnated with polyester.....70A
Lanolin-derivative surfactant yields emulsions.....70B
Shrinkable polypropylene film has high tensile strength.....70C
Urethane foam has silicone additives.....70D
Acetate yarn melts in flame, but is self-extinguishing.....72A
Thermoplastic polyamides have improved properties.....72B
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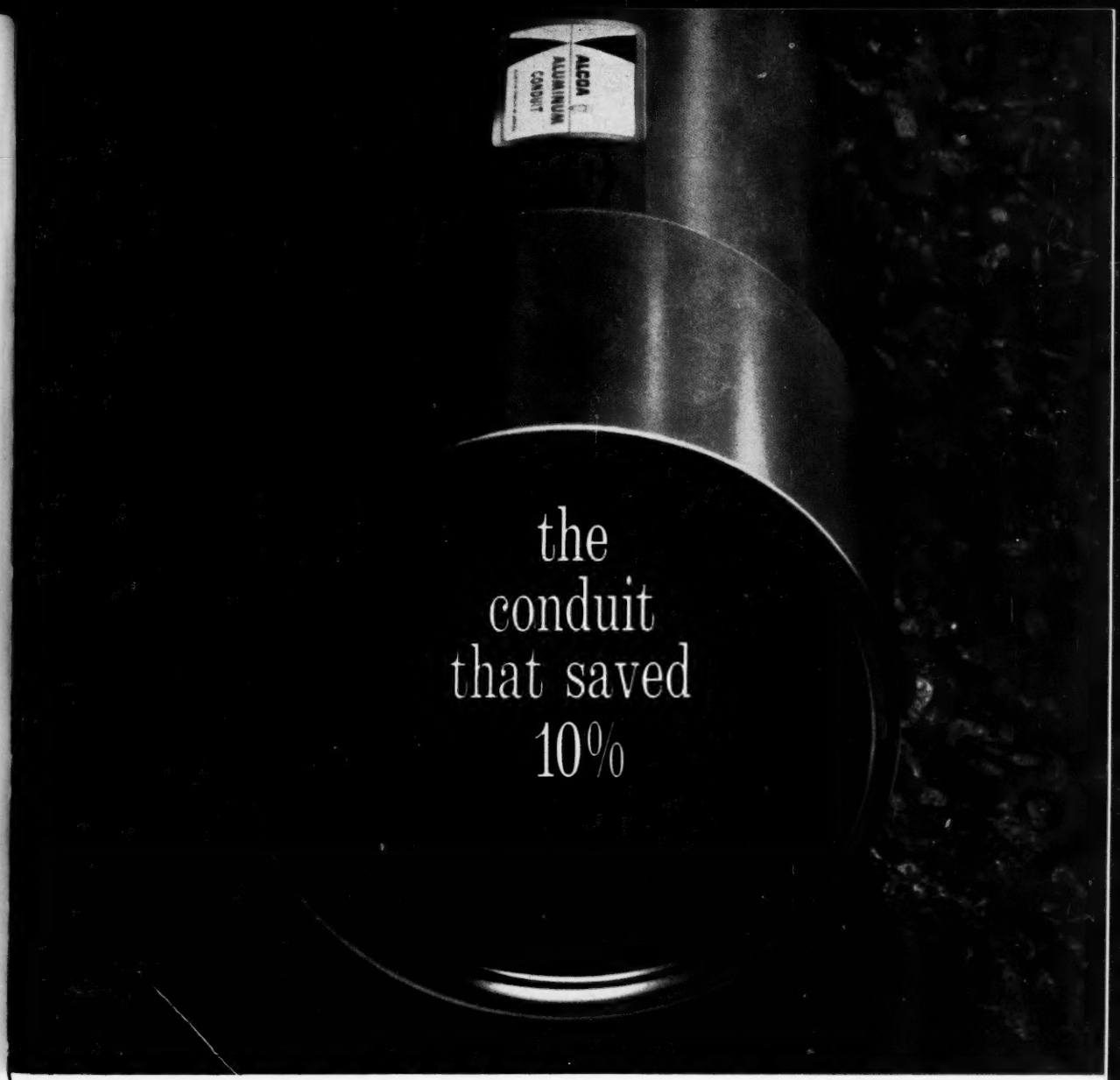
Light-stabilized polystyrene comes in several colors.....72D
Thiophosphate-toxicant emulsifiers are available.....72E
Nonsilicon antifoaming agent has low specific gravity.....72F
Vinyl acetate emulsion is pigment vehicle.....72G

For more details use Reader Service Card



the conduit that saved 10%

What happened at Strick Trailer Company's new plant in Philadelphia when almost two miles of Alcoa® aluminum electrical rigid conduit was installed?

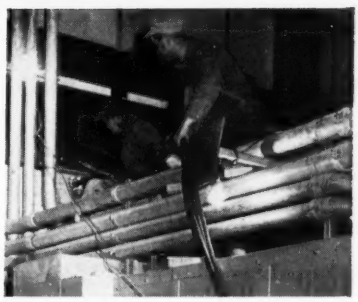
The cost was approximately 10% less than to do the same job in steel.

The reason? Fewer man-hours are required to install aluminum conduit. Based on figures published by NECA in 1959, installation of 100 feet of 4-inch aluminum conduit under a 12-foot ceiling takes 17.5 man-hours; the same installation in steel requires 30 man-hours. In this case, it takes 71% more labor units to install steel.

Aluminum weighs 66% less—pounds that never have to be loaded, unloaded, hefted and suspended. And Alcoa aluminum conduit bends easily, with little or no springback. It is easy to cut and thread; in fact, some studies show labor savings as high as 50% for cutting threads.

Since aluminum is inherently resistant to corrosion, service life is often longer, too, particularly in corrosive environments. No protective coating needed to prevent corrosion. No routine painting required to preserve its usefulness.

How much can you save? The actual dollars depend, naturally, on the nature of your installation. For the complete story, contact your Rome-Alcoa representative. Or write to Rome Cable Division of Alcoa, Dept. 22-111, Rome, N. Y.



SAVED 10% by installing Alcoa aluminum conduit instead of steel at Strick Trailer Company's new Philadelphia plant.

Conforms to ASA C80.5-1960—Rigid Aluminum Conduit and Federal Specification WW-C-540a

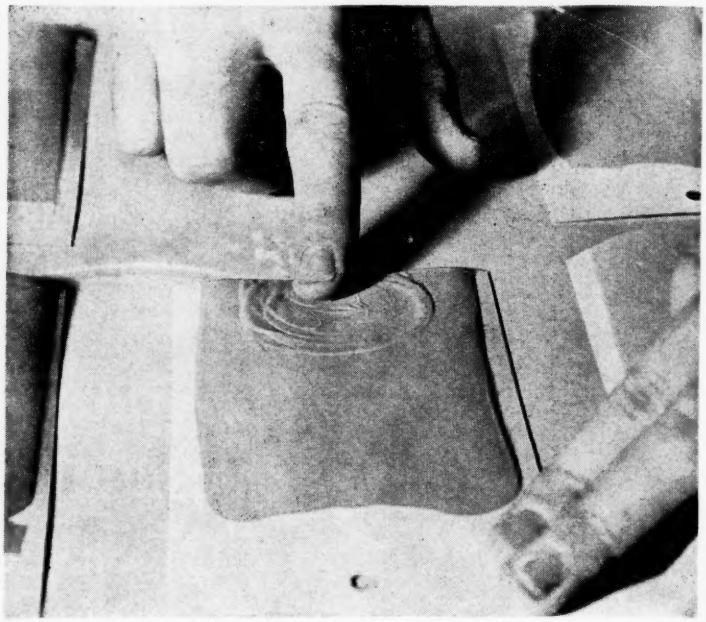
ALCOA
ROME CABLE
DIVISION

that of natural sponge. Called C-2-0145 and C-2-0146, the additives are combined to produce a natural-like pore structure, and can also control the sponge's cavity shape and produce regular or irregular pores.

The urethane sponge is said to be highly absorbent, tough, and resistant to abrasion. Because of its high coefficient of friction, the sponge has good cleaning action.

Although both silicone additives have a price range of $4.50-5.75/lb., their cost in urethane foam formulation is negligible because they are reported effective at concentrations in the 0.02-0.04% range.—**Dow Corning Corp., Midland, Mich.** **70D**

Vinyl acetate emulsion is new pigment vehicle



This is a simple demonstration of full-color development of paints based on Everflex CA, a new vinyl acetate copolymer emulsion. Rubbing action of fingertip produces full colorant distribution in agitated portion. But color in undisturbed area of draw-down is just as deep, proving the emulsion's maximum dispersion of colorants.

Unlike conventional vehicles, Everflex CA needs only small amounts of surfactants to bind pigments with emulsion molecules to insure a good dispersion. Paints made from this emulsion can be applied to interior and exterior masonry to give weather resistance and enhanced appearance.— **Dewey and Almy Chemical Div., W. R. Grace & Co., Cambridge, Mass.** **72G**

Briefs

Acetate yarn has been made flameproof by a flame retardant incorporated before extrusion. The fiber melts when exposed to a flame; if ignited, it becomes self-extinguishing.—**Nelson Silk Ltd., Lancaster, England.** **72A**

New thermoplastic polyamides have been prepared for flexographic and gravure inks, protective coatings and adhesives. Some of their important properties are light colors, increased adhesion, moisture and chemical resistance, improved antigel characteristics. —**Chemco Inc., New York.** **72B**

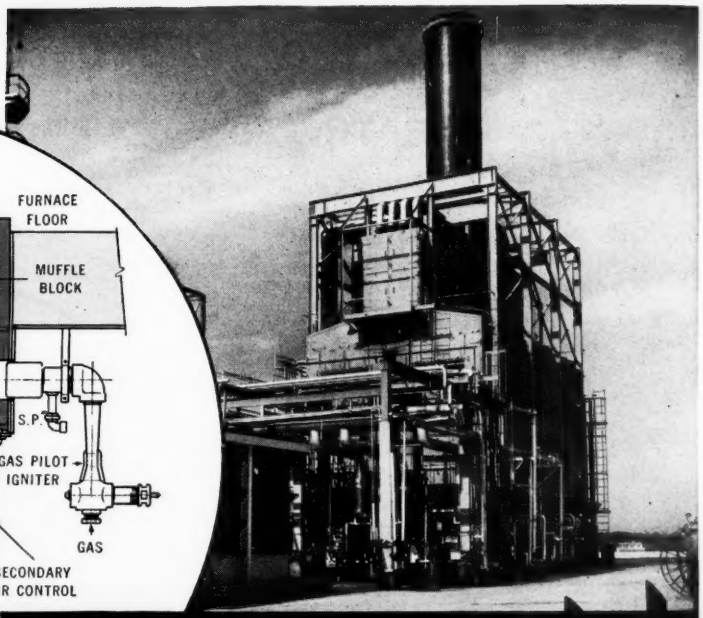
Gold, silver and other precious metals are the components of a new high-temperature lubricant for space capsules and superjet engines. The lubricant, called Hi-T-Lube, is applied in four separate coatings that total less than 0.001 in., and will function perfectly in temperatures up to 1,200 F. Other areas of application are in high-speed machines such as heavy printing presses that require constant attention to lubrication.—**General Magnaplate Corp., Belleville, N. J.** **72C**

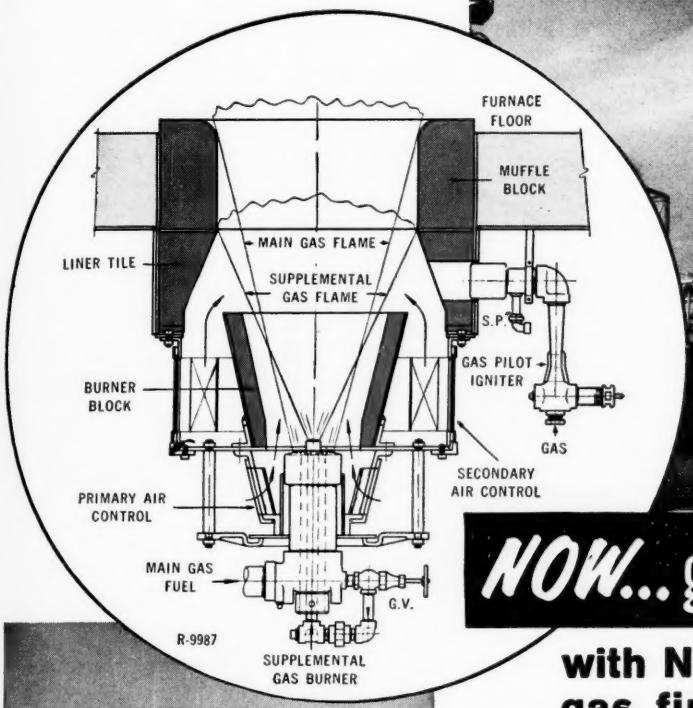
Light-stabilized polystyrene, Styron Verelite 374, is described as a medium-impact polystyrene with excellent color stability under fluorescent-light radiation. Its 20% elongation allows the vacuum forming of a wide range of lighting pans. The material can also be processed in extruders and injection-molding machinery. Manufactured in several granulations and colors, it has a price range of 22-26¢/lb. — **The Dow Chemical Co., Midland, Mich.** **72D**

Thiophosphate-toxicant emulsifiers, Agrimul OQZ and Agrimul ORH, are designed for highly concentrated insecticidal formulations. Agrimul ORH is a blend of anionic and nonionic surfactants for high emulsion stability; Agrimul OQZ is a nonionic product for maximum resistance to hard-water ions. Both are soluble in water and xylene. — **Nopco Chemical Co., Newark, N. J.** **72E**

Nonsilicon antifoaming agent. Ex-Foam 333, has low specific gravity and high bulk value, is almost water-white, doesn't separate, and is claimed to be more than twice as effective as other antifoaming agents.—**Troy Chemical Co., Newark, N. J.** **72F**

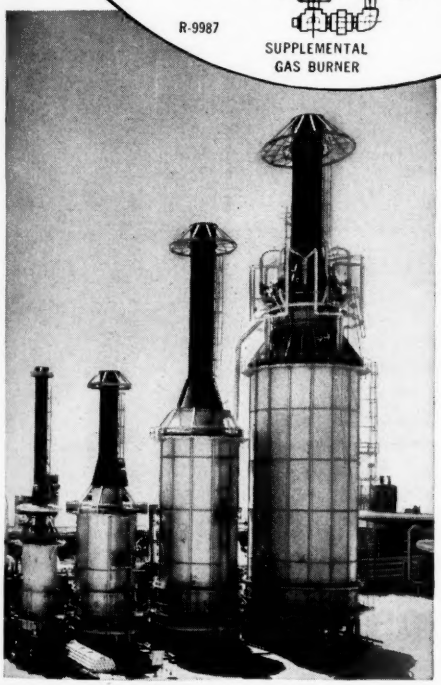
For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 175).





NOW... greater VERSATILITY

with National Airoil C. P. gas firing burner units



Throughout the world . . . in chemical, petroleum, process, pipeline and related industries, National Airoil CHEMICAL-PETROLEUM up-firing burner units are achieving widespread field acceptance. And for good reason!

In accordance with our continuing policy of product improvement, the present design of this gas firing unit (now in actual quantity use) offers several time-and-money-saving "first time" features:

- An increased proportion of combustion air can be induced, partially independent of stack-furnace draft.
- Thorough mixing of the combustion air can be obtained with a minimum of O_2 in the stack gases. Result: high thermal efficiency; maximum radiation heat transfer.
- Capability exists for changing to different gases with some variation in specific gravities and calorific value to maintain approximately the same gas fuel pressures and heat release.
- Proper flame outline can be obtained relative to the furnace dimensions and proximity of tube surfaces.
- An absence of flash or burn back within the burner casting when firing hydrogen-rich gas.
- Regulation ease and capacity flexibility are assured.

National Airoil C. P. gas units can be supplied with a medium pressure gas pilot for electric ignition. A sufficient range of sizes is available to handle standard capacities. A similar National Airoil design also can be furnished for *oil only*, for *combination gas and oil*, or for *forced draft*.

Literature on these versatile C. P. burner units, together with technical and engineering data is available. Why not write for it *today* while you're thinking about it?

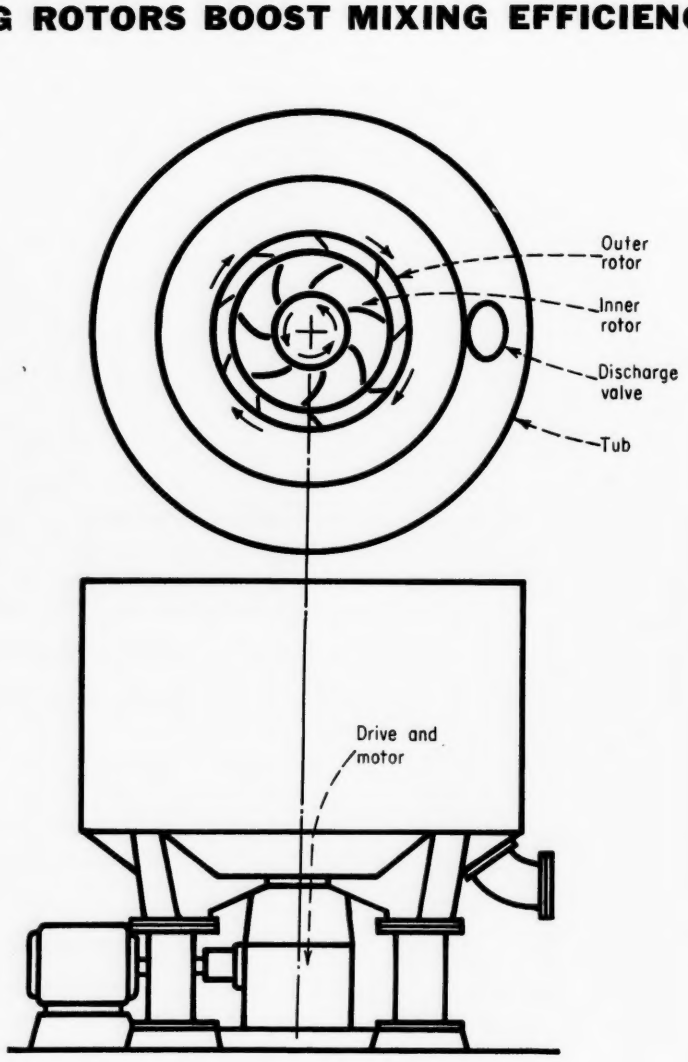
NATIONAL AIROIL BURNER

Established 1912
Incorporated 1917

NATIONAL AIROIL BURNER COMPANY, INC.
1284 E. Sedgley Avenue • Philadelphia 34, Pa., U.S.A.
Industrial Oil Burners, Gas Burners and Combustion Equipment

COUNTER-OPERATING ROTORS BOOST MIXING EFFICIENCY

Bladed inner disk turns one way, outer rotor the opposite direction. The result is high shear force, with most of the power being used for mixing, not circulation.



Almost every improvement in mixing equipment deals with the problem of converting the mechanical input of the motor and shaft into mixing energy in the solids or liquids being blended.

A new mixer called the Dualator is said to have extremely good energy efficiency due to two counter-rotating mixing elements. The inner rotor turns counterclockwise at about 3,000 ft./min., the outer one revolves clockwise at the same speed. The equivalent interfacial speed of 6,000 ft./min. naturally produces a very large hydraulic shear force.

Surprisingly enough, with all this energy being forced into the mixture, the operation is relatively smooth; and batches as small as 25% of design capacity can be thoroughly mixed without producing turbulence and spattering.

▶ **Rotor Design** — Both rotors are driven by a single motor. An input-shaft pinion meshes with the spiral bevel gear of the inner shaft and with the bevel gear of a hollow shaft connected to the outer rotor. Thus, the same pinion rotates the two shafts in opposite directions.

The inner rotor consists of a heavy disk on which are mounted seven triangularly shaped blades, and a central nose cone whose function is to distribute the mixed medium as it is drawn down into the agitation zone.

Surrounding the inner rotor in the same plane is the outer rotor, a circular plate with a circular hole in the center, upon which are mounted nine vanes equal in height to the inner-rotor blades.

Material moving down into the center of the inner rotor is thrust outward in a counterclockwise direction. It passes directly into the path of the outer rotor's vanes, which are moving in a clockwise direction.

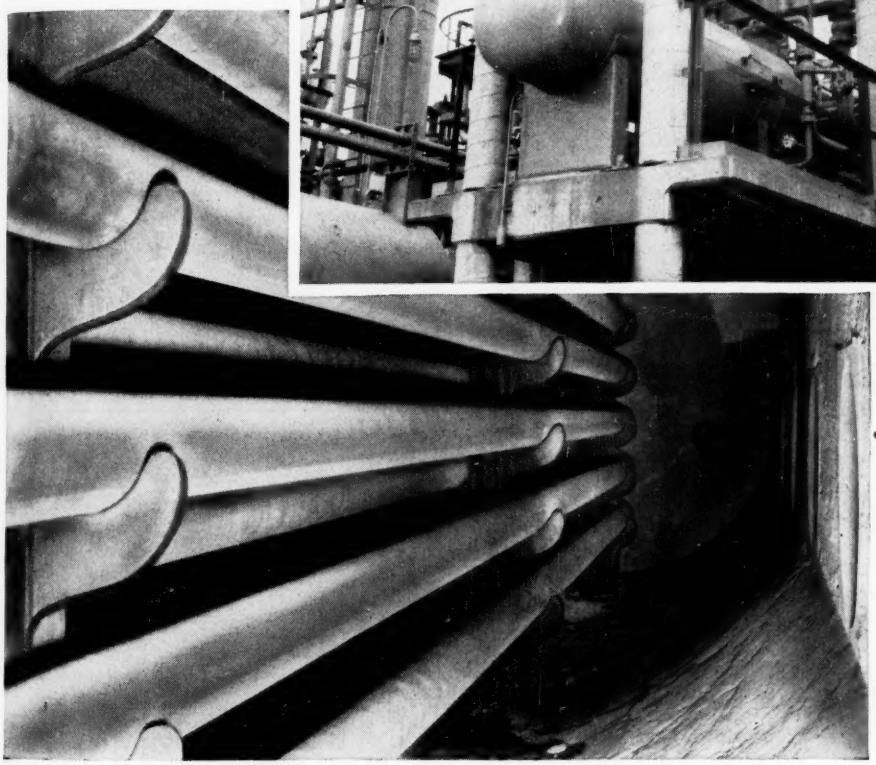
This abrupt reversal in direction at an interfacial speed of over 6,000 ft./min. produces great hydraulic shear force, converting energy effectively into useful work.

▶ **Slow Circulation** — The material being mixed follows the common mixing path: downward in the center, outward across the bottom, up along the sides of the vessel, and down again in the center. But circulation around this path is slow, so that most of the input energy of the rotors is used for intimate mixing, and a minimum is required for circulation.

First devised for paper repulping, the Dualator is said to reduce both defibering time and energy consumption by about one-half over conventional pulpers. For many chemical operations, a similar increase in mixing efficiency may result from this double-rotor mixer. — **John W. Bolton & Sons, Lawrence, Mass.** 74A

STEP 1 ——→

The production of ethylene dichloride. Ethylene and chlorine are blended and charged to the reactor. Reaction products pass through a MONEL Alloy 400 condenser made up of a series of 1 inch tubes, 193 inches long.



STEP 2

The cracking of ethylene dichloride. Ethylene dichloride enters the direct-fired cracking furnace as a dry vapor. The furnace contains INCONEL Alloy 600 extruded tubes 3¾ inches in diameter and 15 feet long. Vinyl chloride is produced in these tubes through the thermal cracking of ethylene dichloride. The tubes, tube return bends, and the inlet and outlet flanges are made of INCONEL Alloy 600.

How 2 Nickel alloys protect vinyl chloride plant against corrosion by HCl and Cl_2

At American Chemical Corporation's new facility at Long Beach, California, MONEL* Alloy 400 and INCONEL* Alloy 600 are helping to increase efficiency and production in this first vinyl chloride monomer plant on the West Coast.

INCONEL alloy 600 and MONEL alloy 400 have excellent resistance to corrosion by hydrogen chloride and chlorine. Both materials combat all types of chloride attack—general corrosion, stress-corrosion cracking, pitting, and erosion-corrosion—at elevated temperatures.

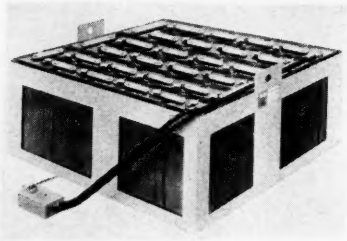
The production of vinyl chloride is only one of many possible applications for MONEL nickel-copper alloys and INCONEL nickel-chromium alloys. If you would like to know more about these corrosion resistant materials, write for our technical bulletins T-5 and T-7. If you need additional help in solving corrosion problems, write to us. Our technical service staff will be glad to assist you.

*Registered trademarks

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17 West Virginia

INCO

HUNTINGTON ALLOYS



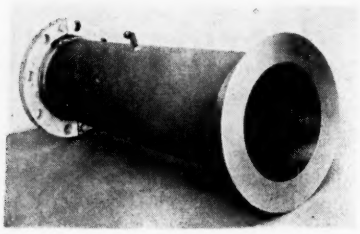
Nickel-iron battery

Capacity is increased by elimination of unproductive volume.

Electrical capacity of a nickel-iron alkaline storage battery has been boosted about 75% by a redesign that takes advantage of all possible space inside the unit.

The percentage of power-producing materials per battery was increased by extending the length of the nickel-steel tubes that contain the positive active material, and increasing the length of perforated steel strips that contain the negative active material. Formerly, these components were arranged in shorter rows having essentially dead space that divided the strips into two pockets.

Cells are now assembled in steel cradles that provide further volume for including more cells. The net effect of the changes is to increase capacity to 100 amp.-hr. per positive plate. Principal uses: for electric trucks, and to provide energy for starting up standby facilities.—**The Electric Storage Battery Co., Philadelphia. 76A**



Flexible valve

Concentric rubber tubes serve for off-on and control applications.

Product flow over a wide temperature range can be regulated by a new valve that consists of two concentric lengths of high-strength silicone rubber. Pneumatic or hydraulic pressure is introduced into the annular space to force the inner tube wholly or partially shut.

In its fully open position, the valve provides no more line resistance than an equivalent length of the same size pipe; partially closed, it produces laminar flow with no turbulence, according to the manufacturer. Closed, it seals gas-tight, and will profile itself around any solid caught in the closure.

The valve will serve from −60 to +600 F., has good resistance to aging and sunlight, is fairly inert chemically, can be sterilized, and exhibits no toxic effect on the product being controlled.—**D. M. Conner & Co., South Plainfield, N. J. 76B**

Temperature controller

Portable unit can also serve for pressure, vacuum and liquid level.

Mercury-in-glass thermometers are used as the primary sensing elements in this controller for regulating temperature within 0.1 deg. C. Device is said to be a true proportional controller, free of the cycling common with on-off units.

For pressure or vacuum control, a clip-on sensing electrode attached to a single or U-tube manometer can detect changes in mercury level, and actuate the instrument. Similarly, an electrode can be clipped on a sight glass for level control, or a sensing probe can be used for direct sensing of liquid level.

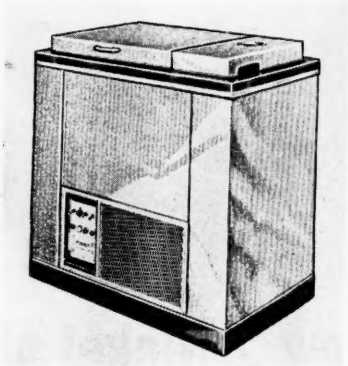
A terminal block on the case permits connection of the unit to any standard milliampere or millivolt recorders if a record of the process is required. For laboratory or pilot-plant use, the instrument is portable.—**Brooks Instrument Co., Inc., Hatfield, Pa. 76C**

Beryllium analyzer

Radiation technique measures Be concentrations as low as 0.005%.

For rapid analysis of ores and process streams containing beryllium, a new analyzer uses a radioactive antimony source. The antimony provides gamma particles to initiate a reaction converting the Be from one isotope to another, with the creation of neutrons.

A newly designed circuit counts the neutrons, detecting as little as 5 milligrams of BeO in a 100-g. sample. Accessories include a survey meter, dosimeters, chargers and standard samples.—**Kleber Laboratories, Inc., Burbank, Calif. 76D**



Isothermal bath

Water temperature is regulated within 0.25 degree over 0-100 F.

Pilot-plant or laboratory tests that call for a circulating supply of hot or cold water for temperature regulation can be performed with the aid of a new isothermal circulating bath.

In the range of 0-100 F., the bath will keep 20 gal. of water, oil or other suitable liquids within ±0.25

BETTER than one

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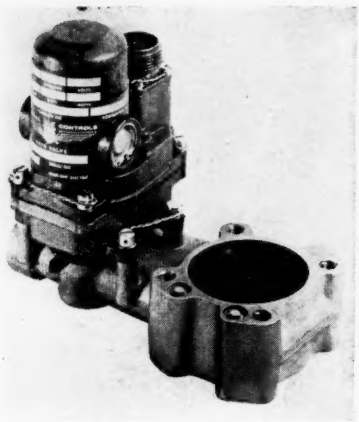
F. of the desired temperature. A built-in pump circulates the liquid through a test setup at the rate of 1.6 gpm. at zero head, or 0.8 gpm. against a 5-ft. head.

Cooling capacity of approximately 890 Btu./hr. is provided by a mechanical refrigerator that circulates Freon 12 through copper coils on four sides of the bath. Heating capacity of 2,950 Btu./hr. is accomplished with two immersion heaters: a 750-w. unit to bring the bath temperature up quickly, and a 300-w. control heater. — **Fisher Scientific Co., Pittsburgh. 76E**



Motorized gate valve

Miniature device is suitable for gas, oil and fuel control.

Said to be the smallest motor-operated gate valve in production, a miniature unit measures 6 × 3 in., weighs 2 lb. With an operating time of 1 sec., the device includes a position indicator, manual over-ride, stainless steel gate and full port.

Operating range is −65 to +135 F., at up to 60 psi. It is equipped with 6, 12, or 24-v. d.c. motor or 120-v. a.c. motor.—**Industrial Controls Div., General Controls Corp., Glendale, Calif. 78A**

For more information about any item in this department, circle its code number on the Reader Service Postcard (page 175).

Temperature controller

Proportional-control unit is based on switching-time modulation.

Said to provide precision in controlling temperatures, a device known as a phototransistorized proportional controller operates on the principle of a light beam being interrupted when a preset point is reached.

Placed on the market recently by a Dutch firm, the unit is adaptable to the regulation of other functions as well as temperature. Its proportional action works on the principle of switching-time modulation.

When a variable attains the proportionality area as it nears the preset point, the switching relay breaks the output circuit periodically; as the controlled function increases, the circuit is broken for a larger proportional time. Modulation action has no effect on indicator action.—**Netherlands Consulate General, New York. 78B**

pH controller

Automatic device regulates, monitors and records pH in process.

For process operations where solution pH must be closely controlled, this new apparatus has its own indicating pH meter and strip-chart recorder integrated with a peristaltic-action addition pump and a set of timers.

The desired pH level is automatically maintained as small quantities of buffer solution are added to the reaction vessel. The pump can be set to operate for periods from 0 to 15 sec., depending on the working volume or the speed of the reaction.

A variable time delay between buffer-addition cycles allows buffer solution to be mixed in the reaction vessel; the process is repeated until the solution pH corresponds with the control setting. For fast reaction speed, timers can be continuously energized to maintain desired pH with a tolerance of 0.1.

Two models are available—one to control either acid or base, the other for dual control of both.—**New Brunswick Scientific Co., Inc., New Brunswick, N. J. 78C**

Vibrating mixer

Specially perforated plate fixes direction and velocity of mixing.

Utilizing principles akin to those found in ultrasonic equipment, a new mixer receives its energy from an electrical vibrator. A mixing plate, containing a number of specially shaped openings, vibrates on the end of a long rod to introduce energy into the medium being mixed.

In operation, the unit is suspended above or through the tank or vessel so that the appropriate driving plate is submerged in the liquid. The plate can be mounted with its openings facing up or down, and the direction and velocity of mixing motions can be controlled by use of various plates and types of openings.

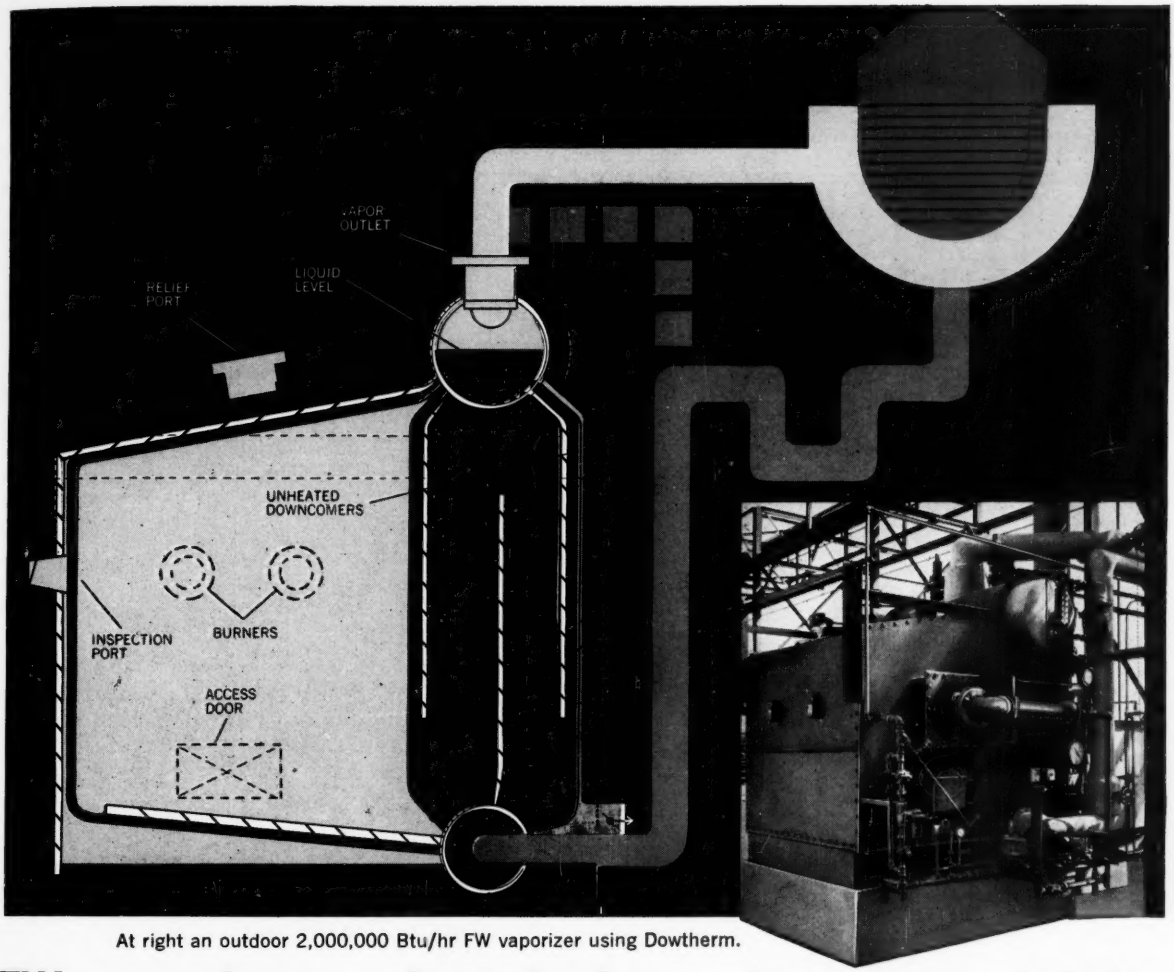
Said to produce a uniform product with a minimum of aeration, the Vibro Mixer is portable, can be set up quickly for different applications.—**Crown Cork & Seal Co., Inc., Philadelphia. 78D**

Surface thermocouple

Magnet makes close contact without marring measured surface.

Want to find the temperature of a surface without actually attaching a thermocouple probe? A new unit consists of a permanent magnet that may be placed on any magnetic surface in any position.

New Equipment continues on page 152



At right an outdoor 2,000,000 Btu/hr FW vaporizer using Dowtherm.

FW vaporizers...less to buy...less to maintain

By surveying and understanding your entire process, Foster Wheeler engineers are able to tailor your vaporizer and its auxiliaries exactly to your needs. By thus avoiding over- and under-design, you are assured minimum first cost consistent with dependable economic performance.

FW natural circulation vaporizers and their adaptability to gravity return systems mean fewer moving parts, lower power consumption, reduced pump cost and maintenance, and greater accessibility. Such units also use a smaller quantity of valuable heating medium.

In addition, FW vaporizers offer unusually sensitive heat control by eliminating flash-down to achieve precise final temperatures. This means instant response to temperature variation and reduced degradation of the heating medium . . . protecting your investment in it.

FW vaporizers do all of this with fewer control devices and less auxiliary equipment than recommended with other vaporizers. With less to buy and maintain, both first cost and operating overhead are held down. By surveying and understanding your entire process the most practical piping arrangements can be made to allow for optimum heat transfer as well as operator convenience.

Over the last 26 years Foster Wheeler has supplied over 700 organic heating systems for every application and capacity, from the smallest on up to single units delivering in excess of 50,000,000 Btu/hr. Get full benefit from this broad experience by discussing your requirements with Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

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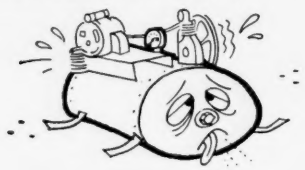
ONE OF A SERIES OF CHATS ABOUT THE CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

PREVENTION OF CRUELTY TO OLD COMPRESSORS

You've got at least one air compressor, of course. Doesn't everybody? And there it sits, pumping its heart out for you year in and year out. And you there, Simon Legree, do you ever give it a break and measure its capacity?

One measure is the useful work done by your compressed air tools, of course. However, this yard stick may make your compressor installation seem way oversize, but don't blame the equipment. The puffing oldster isn't responsible for choked intake filters, poorly designed suction pipes,



overcooling, undercooling, inadequate distribution mains and wet air. All these things can cost you.

Off and on we're going to talk about compressors in these pages, if you don't mind. It's a big subject and the lesson for today will be confined to the air intake. Can you imagine a more logical place to start?

Where to locate the intake? Easy. Where the atmosphere is clean and cool and dry. Dirty air and grit choke filters and eventually get through to cause wear. The cooler the air, the more you can compress per revolution. You'll get 10% more air delivered at 40°F. than at 90°F. And dryness is imperative, because compressed air can't contain all the moisture it can hold in its uncompressed state. Where does the moisture go? Into mains, tools, and valves, unless it's removed. And need we add that chemical fumes cause corrosion? That includes exhaust gases from engines and furnaces. CO_2 in the presence of oxygen and moisture can rust your valves, tools, nozzles and sprays.

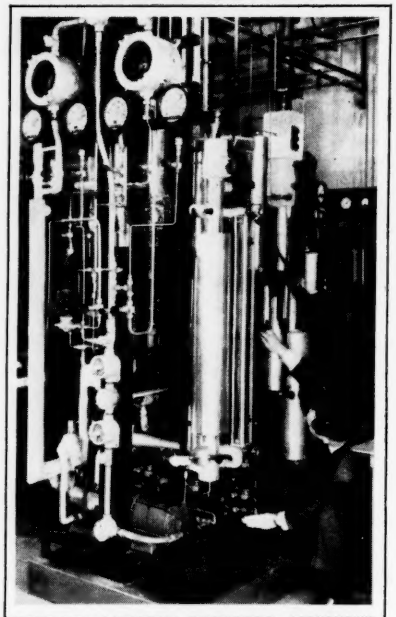
How about intake size? Keep pipes short, sized right, and straight as possible. Small pipes with snaky bends reduce pressure and capacity. For an educated example, a pressure loss due to friction in the intake pipe and filter of 2 psi (14.7 to 12.7) will reduce output of a 125 psi compressor by 7.5%.

How do we know so much? Well, as we continue in future issues, we'll be talking drains and traps and cooling and safety controls for compressors—all of which we manufacture. That's how we know so much. If you can't bear to wait, just write. It's that easy to get information out of us.

SARCO AND THE FLYING DUTCHMAN

In the pipe shop of a major office building complex on New York's east side, the Flying Dutchman flies again. This is really a bright idea which could well become standard practice elsewhere, because it's the kind of logical precaution that would make sense anywhere.

The chap in our photograph is putting together, according to precise, dimensioned drawings, an assembly consisting of a Sarco Thermo-Dynamic Steam Trap, Type TD-50, a Sarco strainer, and valves and fittings for stock. The assemblies will be used for quick and easy replacement in the event of failure or any possible maintenance requirement in the steam distribution system, the heating system, or the air conditioning system.

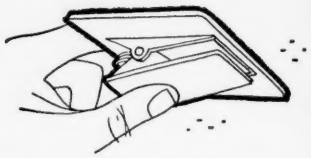


WORLD'S LARGEST ESPRESSO MACHINE?
No indeedy. It's a pilot plant Hydrofiner unit built by The Lummus Company at its Engineering Development Center in Newark, New Jersey. And its presence here is due to the fifteen ⅜" Sarco Thermo-Dynamic Steam Traps which vent and drain its 35 pound tracer lines plus a ½" TD-50 as a main drip. Nice to be picked for projects like this. Makes us proud.

We'd like to be able to report that this plan recently saved thousands of people from freezing or roasting during a crisis. So far, however, the assemblies have proved to be an ornamental kind of insurance policy. Alas, there have been no failures. That dog-goned Sarco performance is just too reliable for its own good.

WE'VE GOT THINGS TO GIVE AWAY

First of all, we have a new spring clip to hold together a bunch of papers on your desk, or something. It's not complicated, but it *is* difficult to describe, so we've gone to the tremendous expense of having our local Michaelangelo sketch it here. If you have no papers to hold together, it makes a rather delightful snapping noise that might amuse you. Oh yes—it also has a cross section of a TD-50 steam trap printed on it which actually *moves* when you wiggle your eyeballs at it. In case you *still* don't know how a TD-50 works, this is for you.



Second, we've still got engineers' sketch pads which we enjoy giving away so much we're offering them again. In case you're new here (Hello!) they contain isometric grid paper for use by anyone involved in piping or hookup sketches for process or heating applications.

And the famous Sarco key chain, which is really exactly that—a chain—about 60 times as handy as a fat case, we're offering again too. This has a TD-50 replica attached, but detachable. Call it tawdry promotion if you will, but our super-aesthetic wife wears one proudly around her neck.

All of these are available from your Sarco representative. Or, if he's out, write in.

There's really no reason to keep this conversation one-sided. After all, we're both interested in these subjects or you wouldn't have read this far. So write, even if it's only about a difficult problem. 7826

SARCO COMPANY, INC., 635 MADISON AVE., NEW YORK 22, N.Y.

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

SARCO

Please don't feed the "TUBE EATERS"

Don't let unnecessary pitting, cracking or erosion chew up tubes before their time. Don't let *any* type of corrosion, scale or biofouling hamper your heat exchange efficiency without checking these four factors:

• Is the tube alloy *right?* Will a vital difference in corrosion resistance result from a minor alloy change—or is an entirely different alloy called for? • How much will performance be improved by Duplex bi-metallic tubes which provide the best metal or alloy for *each* heat transfer medium. • Will a change to thickened-end or thickened-center tubes give needed extra resistance where attack is most severe? • What actual data on similar exchanger operations are available?

We at Bridgeport can help you. Our condenser tube experience dates back to 1900 but our files are completely up-to-date on tube problems reflecting the high pressures, temperatures and velocities of modern operations. Write Bridgeport Brass Company, Bridgeport 2, Connecticut.

Bridgeport condenser and heat exchanger tubes in over 50 metals and alloys:

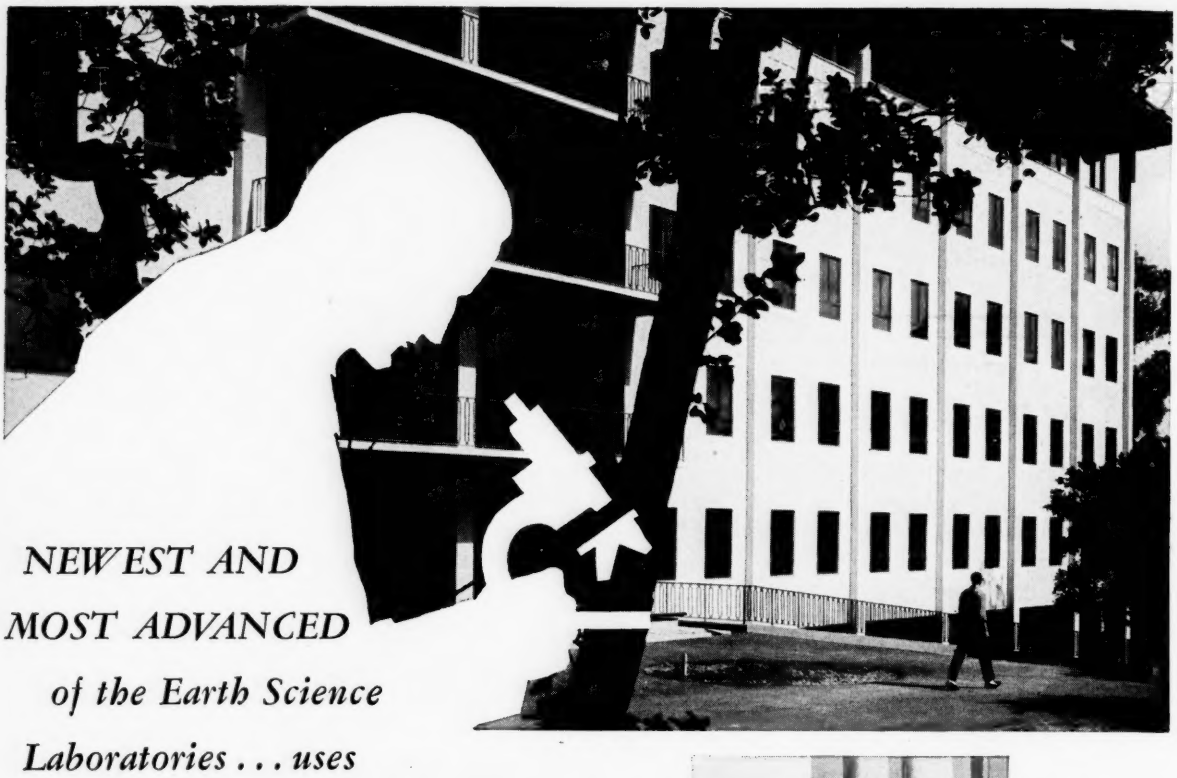
INHIBITED ADMIRALTY
INHIBITED ALUMINUM BRASS
INHIBITED MUNTZ METAL
70-30 CUPRO NICKEL
90-10 CUPRO NICKEL
DEOXIDIZED ARSENICAL COPPER
INHIBITED ALUMINUM BRONZE
RED BRASS
ALLOY 77 MERCURY BRASS

...plus **DUPLEX TUBES**...in combinations of the above alloys, with carbon or stainless steel, aluminum, Monel,® nickel...or other metals.

BRIDGEPORT BRASS COMPANY

Bridgeport

ARCHITECTS: Warnecke and Warnecke. GENERAL CONTRACTORS: Rothschild, Raffin and Weirick, Inc. MECHANICAL CONTRACTORS: Herman Lawson Company. (All of San Francisco)



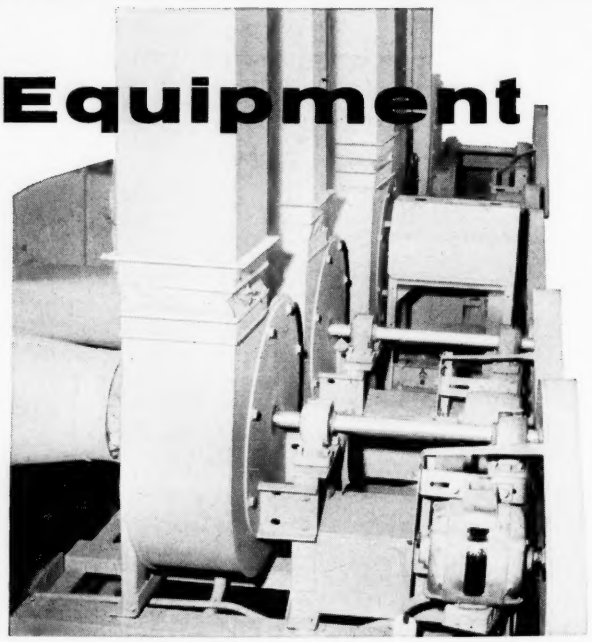
NEWEST AND MOST ADVANCED of the Earth Science Laboratories . . . uses

CLARAGE Equipment

ASSIGNMENT: AIR HANDLING in this new six-story, reinforced concrete structure for the Study of Geography, Geology, and Paleontology at a leading West Coast university.

Aiding students, staff, and classroom experiments are 39 Clarage Fans in general comfort and specialized laboratory hood exhaust applications.

Yes, for notable buildings the world over, Clarage air handling and conditioning equipment is a frequent choice because of its long-standing reputation for quiet, economical, dependable service. You too can profit by investigating the *quality* line we manufacture for buildings of all types, all sizes.



Largest of the 39 Clarage Fans installed on this particular job has a wheel diameter of 54¼" in double width construction. Shown here are a few of the smaller units in service.

Dependable equipment for making air your servant

CLARAGE FAN COMPANY

Kalamazoo, Michigan

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

The new expanded Pluronic Grid...

another key chemical approach from Wyandotte

VOLUME III

A research short cut for formulators

Since the 1956 publication of our "Pluronic Polyol Grid Approach" great growth has been experienced by these block-polymers, both as surfactants and chemical intermediates.

The variety of Pluronic grades has grown from 6 to 30 . . . in addition, there are a number of commercially available mixtures and modifications of regular grades.

Eight new members that comprise the 9 and 10 series Pluronic polyols are of special interest. These polyols complement and enhance the versatility of the other members of the series.

The physical properties of the new members are less temperature sensitive than those of lower molecular weight. Most all of the new members show greater surface tension reduction, allowing for much better wetting. Those grades in the solid form possess sufficiently high detergent properties to indicate promise for use in formulated bars or tablets. The new 9 and 10 series of Pluronic polyols also opens the entire field of emulsification applications (e.g., typical xylene-water system emulsions, based on Pluronic polyols, remained stable through several successive freeze-thaw cycles).

This material and more is contained and described in the new expanded Grid. A proved, practical research short cut for formulators, the Pluronic Grid approach is of inestimable value as a means of systemizing their research . . . helping to eliminate random evaluation of unrelated materials.

What singles out the Pluronic series

Chemists know that polyoxyethylene compounds are water soluble—no matter how high their molecular weight. For many years it was generally assumed that polyoxypropylene compounds would also be water soluble. However, the fact is: at a molecular weight of about 800-900, polyoxypropylene glycols become essentially water insoluble. As the molecular weight of this chain increases, it becomes more hydrophobic.

Investigation at Wyandotte (U.S. Patent #2,674,619) revealed that if water-soluble polyoxyethylene groups were added to both ends of the water-insoluble polyoxypropylene chain, a complete series of new block-polymers with highly desirable surface-active properties could be obtained.

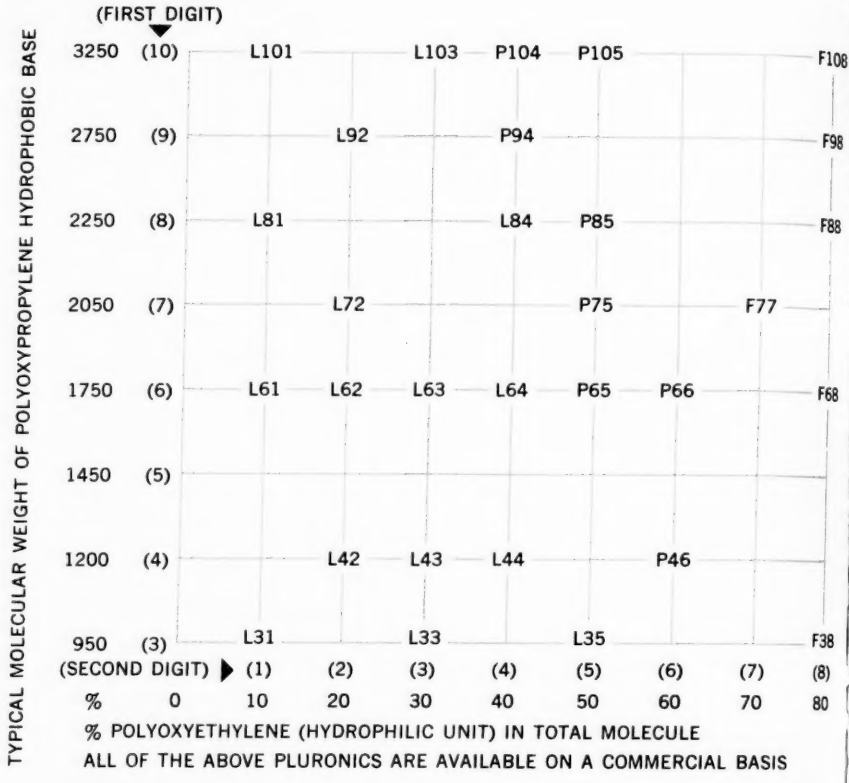
These block polymers are prepared by adding propylene oxide to the two hydroxyl groups of a propylene glycol nucleus. The resulting hydrophobic base can be made to any controlled length, varying from 800 to many thousands in molecular weight.

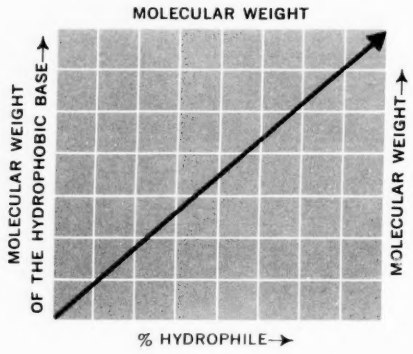
By adding ethylene oxide to both ends of this hydrophobic base, it is possible to put polyoxyethylene hydrophilic groups on the ends of the molecule. These hydrophilic groups are controlled in length to constitute anywhere from 10% to 80% of the final molecule. The simplified structure can be represented as:

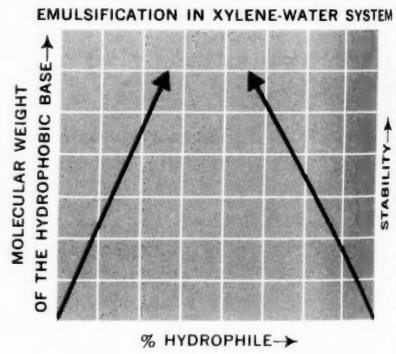
$$HO\,(CH_2\text{-}CH_2\text{-}O)_a\,(CH\text{-}CH_2\text{-}O)_b\,(CH_2\text{-}CH_2\text{-}O)_c\,H$$
$$\qquad\qquad\qquad\qquad\quad |$$
$$\qquad\qquad\qquad\qquad CH_3$$

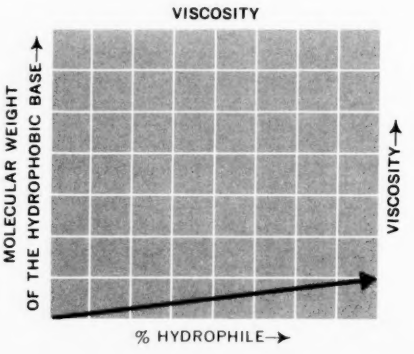
Other products on the market can usually vary only the hydrophile. The Pluronic polyols are unique in that the size of *both* the hydrophobe and the hydrophile are variable, offering an additional dimension of freedom. This produces a wider range of properties, which vary in smaller, more controllable increments.

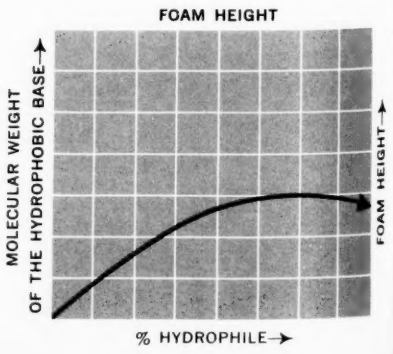
PLURONIC GRID

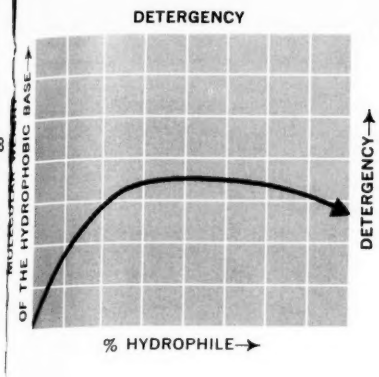

(FIRST DIGIT)
TYPICAL MOLECULAR WEIGHT OF POLYOXYPROPYLENE HYDROPHOBIC BASE
3250 (10) L101 L103 P104 P105 F108
2750 (9) L92 P94 F98
2250 (8) L81 L84 P85 F88
2050 (7) L72 P75 F77
1750 (6) L61 L62 L63 L64 P65 P66 F68
1450 (5)
1200 (4) L42 L43 L44 P46
950 (3) L31 L33 L35 F38
(SECOND DIGIT) (1) (2) (3) (4) (5) (6) (7) (8)
% 0 10 20 30 40 50 60 70 80
% POLYOXYETHYLENE (HYDROPHILIC UNIT) IN TOTAL MOLECULE
ALL OF THE ABOVE PLURONICS ARE AVAILABLE ON A COMMERCIAL BASIS

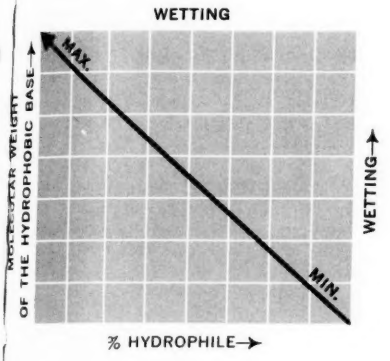


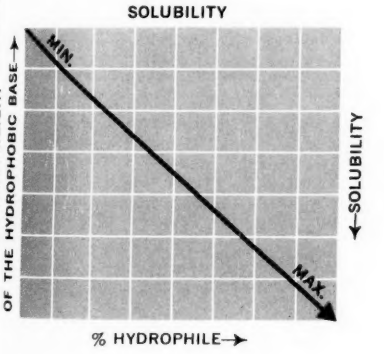


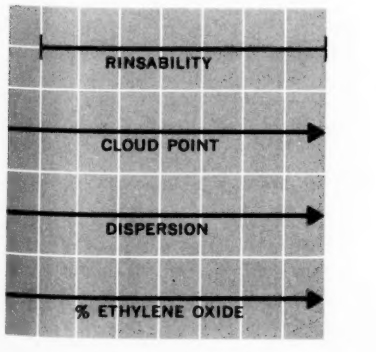












The Pluronic polyols range in physical form from mobile liquids to solids sufficiently hard to be flaked. They are 100% active in all forms, and exhibit a wide variety of surface-active properties. They range in molecular weight from 1,000 to over 16,000. They vary from materials that are almost water insoluble to materials that have no cloud point—even at the boiling point of water.

Identification of Pluronic Polyols

To simplify the naming of the Pluronic polyols, they are identified by a letter (L, P, or F) and a number. The letter identifies the physical form of the particular Pluronic polyol: L for liquid, P for paste, F for flake. The first digit or digits identify the typical molecular weight of the hydrophobic base, as indicated by the column to the left of the Grid. The last digit indicates the approximate per cent of ethylene oxide in the total molecule.

Thus, Pluronic F108 is a flake with a typical hydrophobic-base molecular weight of 3250; approximately 80% of the molecule, by weight, consists of hydrophilic polyoxyethylene groups, and the remaining 20% is the hydrophobic polyoxypropylene group.

Total molecular weights of the Pluronic grades can easily be approximated. For example:

$$\text{Molecular weight of F108} = \frac{3250}{.20} = 16250$$

3250 is the typical molecular weight of the polyoxypropylene base for those Pluronic grades whose first digits are 10. And .20 means that approximately 20% of the molecule, by weight, is polyoxypropylene.

The Pluronic Grid approach and its advantages

The Pluronic Grid is a graphic representation of our broad series of Pluronic polyols, formed by plotting molecular weight ranges of the hydrophobe against the per cent of the hydrophile in the final molecule. In brief, these are the advantages:

1. *Provides a controlled systematic method of screening.*
2. *Minimizes costly random screening by establishing property trends.*
3. *Offers a single method of determining the effects of changes in molecular weight and in hydrophobic-hydrophilic ratio.*
4. *Helps develop new products and processes by the accumulation of information on related grades of the Pluronic series that would have been impossible with random screening of other surface-active agents.*
5. *Permits the chemist to find the Pluronic or combination of Pluronics with the best balance of properties for the solution of his problem instead of trying to formulate to a surfactant's properties.*

How to use the Pluronic Grid

Because of the wide range of molecular weights obtainable in the Pluronic series—and because of the two degrees of freedom (controlling the molecular weights of both the hydrophobe and the hydrophile)—properties of the Pluronic grades can be plotted as trends across the Grid.

By observing these trends, the formulator can select—from the Grid—those Pluronic grades having the best balance of properties for his particular application. After only a few laboratory tests, he can narrow this area down to the best Pluronic polyol or combination of several grades for his formulation.

Known trends for several general properties of the Pluronic series are shown; other specific trends can be determined easily by evaluating a few Pluronic grades from various positions on the Grid. In this way, it is possible for anyone to plot his own trends . . . individual trends directly pertaining to his own operations, conditions, or problems.

Example I:

Formulation of an Insecticide Compound

In formulating an xylene-type insecticide, it is desired to add a surface-active agent having the following properties:

1. *It must be a good emulsifier.*
2. *It must have low foam.*
3. *It must cause good wetting.*
4. *It must possess good lime-soap-dispersing ability.*
5. *It must be soluble in cold water.*

Rather than initiate a random evaluation of all the unrelated surface-active agents now commercially available, the formulator can save research time—and direct his efforts in an organized approach to the problem of selecting a suitable sur-

factant—by referring to the Pluronic Grid.

The emulsification property is perhaps the most important. The polyols at the top center of the Grid give the best xylene-water emulsification properties. The members of the series in the upper right quadrant show the best lime-soap-dispersing, while the members in the upper left quadrant show the best wetting properties. The lowest foaming members of the Grid are on the extreme left-hand side. Being nonionic, the Pluronic polyols are inversely soluble with temperature . . . all of the members of the series possess good cold-water solubility characteristics.

Since emulsification, good wetting and good lime-soap-dispersion are the most important properties, the formulator should evaluate the Pluronic grades **L103, P104, L92** and **P94**. This systematic approach to the problem can eliminate much fruitless work in the unprofitable areas.

In actual tests on the xylene-water system, Pluronic **L103** has appeared to be the best member in the series for this application.

Example II: Formulating a Home Laundry Detergent Compound

The surface-active agent used in a detergent should have the following properties—low to moderate foam, solubilizing ability for lime soaps, good detergency and good rinsability.

As you proceed across and up the Grid, the foam characteristics of the Pluronic polyols increase to a maximum and then decline.

Pluronic polyols with the best soil removal properties are found in the center portion of the Grid. All of the Pluronic polyols are excellent lime-soap-dispersants; the most efficient are located in the upper right-hand quadrant. All of the Pluronic polyols exhibit excellent rinsability.

Since rinsability, desired foaming characteristics, and detergency are the most important properties, the formulator should evaluate Pluronic grades **L62, L63, L64, P65** and **P75**, or **F68, F77, F88, F98** and **F108**, if a solid surfactant is desired.

By applying this systematic approach, the formulator can eliminate much fruitless work and extensive testing of many unrelated surface-active agents.

The PLURONIC

series has a growing list of commercial applications

Agricultural Products: Emulsifiers; emulsion stabilizers; dispersing and wetting agents.

Cosmetics: Deodorants; hair preparations; lotions; oral-hygiene products; shampoos*.

Formulated Detergents: Laundry products*; dairy cleaners; detergent sanitizers; floor cleaners; rug cleaners; mechanical-dishwashing products*; rinse aids*; scouring powders; foam level control.

Latex and Rubber: Stabilizers; viscosity regulator for styrene-butadiene latices; vulcanizers.

Lithography: Dampener roll cleaners*.

Metal Cleaning: Alkaline metal cleaners*; aluminum anodizing; passivating; steel pickling.

Metal Cutting: Water-soluble coolant and lubricant formulations*; resinoid grinding wheels*.

Paint: Emulsion paints*; pigment dispersing; improved leveling, spreading, and brushability; viscosity control.

Paper: Coating colors*; reducing viscosity; pigment dispersing; latex stabilizing.

Pharmaceuticals: Dispersants for antibiotics; solubilizers for antibiotics and vitamins.

Petroleum: Demulsifying agents; dispersants and lubricants for drilling muds; wetting agents for secondary recovery.

Plasticizers: Methylmethacrylate, phenol-formaldehyde, urea-formaldehyde, and polystyrene resins.

Polyurethane Resins: Reacting with diisocyanates to give economical foams of superior properties.

Soap: Soap-synthetic and all-synthetic bars; lime-soap dispersant.

Textiles: Desizing formulations; antistatic agents; continuous hypochlorite bleaching; dye leveling*; kier boiling; soaping-off prints; softening warp sizes.

Water Treating: Boiler water; scale prevention in industrial water supplies.

And in many other miscellaneous uses such as: Defoaming agents; mold-releasing compounds; water flooding; etc.

**Technical Data Sheets available upon request.*

The Pluronic Grid can help you choose the proper chemicals for testing, but only a thorough evaluation in your own laboratories can give you the full scope of what the Pluronic polyols can do for you. Write today for samples, general listing of physical properties, data sheets pertinent to your application, and other technical information. Wyandotte Chemicals Corporation, Wyandotte, Michigan. Offices in principal cities.

WYANDOTTE CHEMICALS

MICHIGAN ALKALI DIVISION

SODA ASH • CAUSTIC SODA • BICARBONATE OF SODA • CALCIUM CARBONATE
CALCIUM CHLORIDE • CHLORINE • GLYCOLS • SODIUM CMC • ETHYLENE OXIDE
ETHYLENE DICHLORIDE • POLYETHYLENE GLYCOLS • PROPYLENE OXIDE • PROPYLENE
DICHLORIDE • POLYPROPYLENE GLYCOLS • SURFACE-ACTIVE AGENTS • DICHLORODI-
METHYLHYDANTOIN • CHLORINATED SOLVENTS • URETHANE FOAM INTERMEDIATES
DRY ICE • OTHER ORGANIC AND INORGANIC CHEMICALS

FORM NO. 189-61

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DE LAVAL

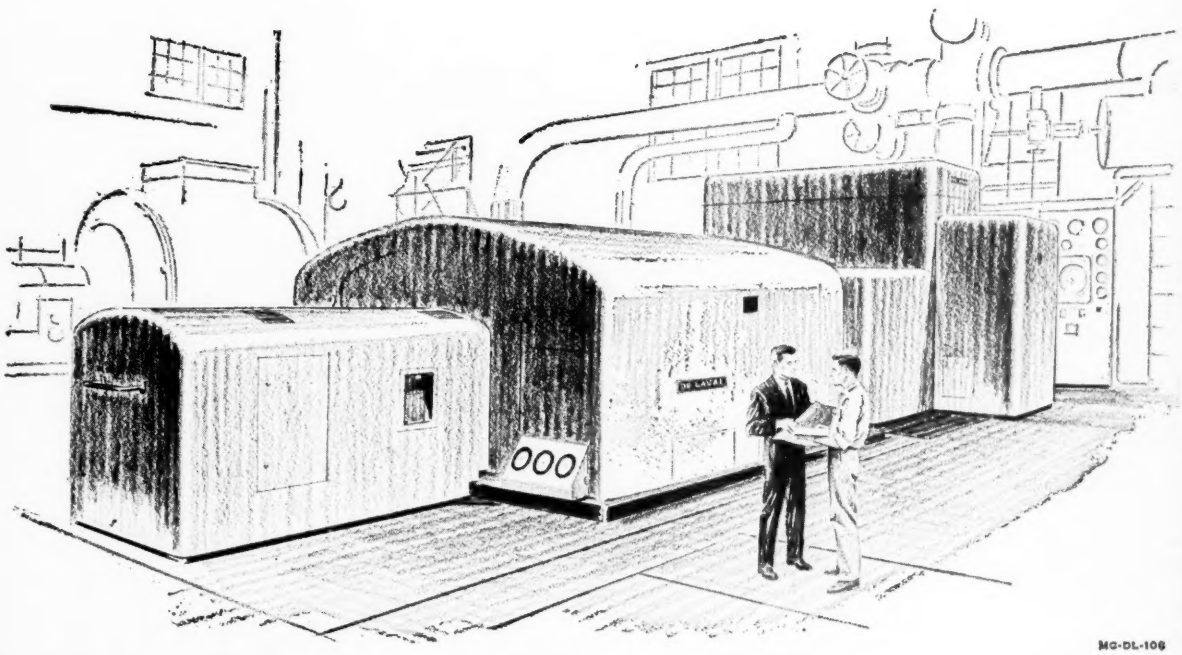
engineered flexibility lets a turbine "grow"

With his eye on tomorrow, a major food processor gave De Laval unusual requirements. He wanted a turbine that would meet today's power and process steam needs . . . and be capable of almost doubling its output in the future. The result: a De Laval turbine to which five additional stages can be added in the customer's plant.

Present capacity of this unit is 5,000 kilowatts which will be raised to 9,375. For future operations, steam pressure and temperature will also be sharply increased.

Whether you need a turbine that can "grow" or have other problems involving heavy rotating machinery, De Laval engineered flexibility can help.

De Laval Steam Turbine Company, Trenton 2, N. J.



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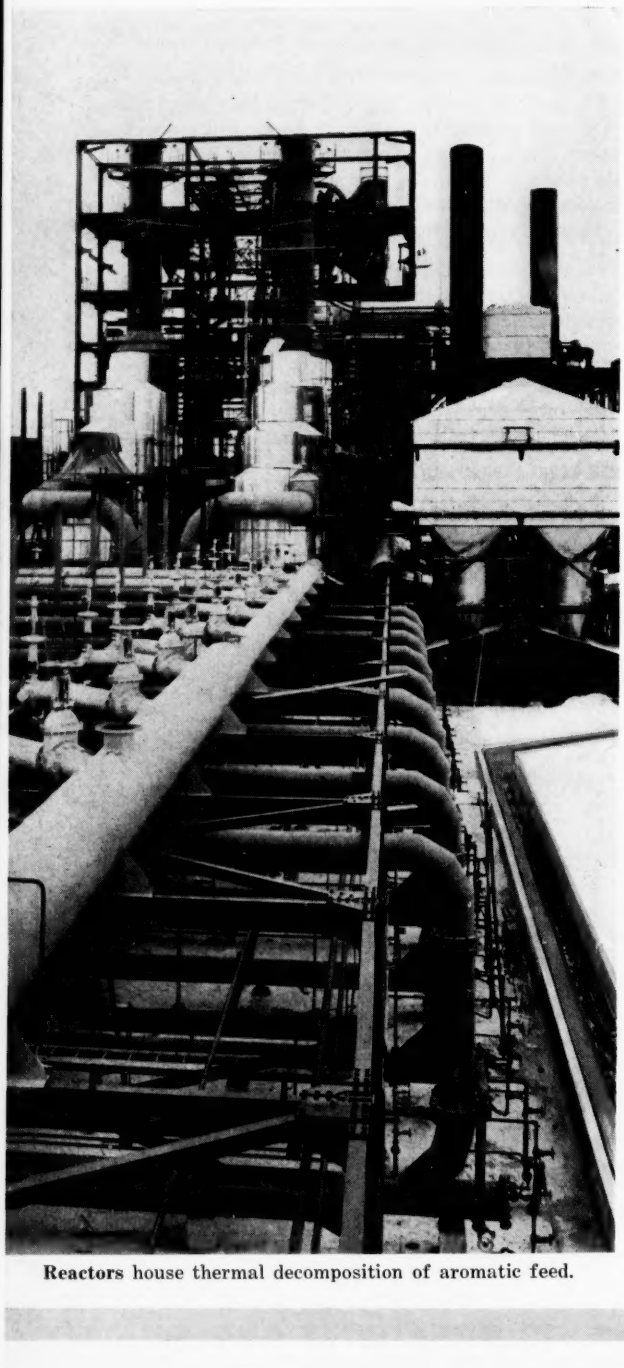
MARINE PROPULSION AND AUXILIARY EQUIPMENT • HELICAL AND EPICYCLIC GEARS • TURBOCHARGERS

Process Flowsheet

New Entry Spurs Carbon-Black Boom



Reactors house thermal decomposition of aromatic feed.

Growth of carbon-black capacity, particularly overseas, is highlighted by this look at a big, new French plant. It has markedly cut that country's import needs, and blends well into the surrounding industrial pattern.

N. P. CHOPEY *Assistant Editor*

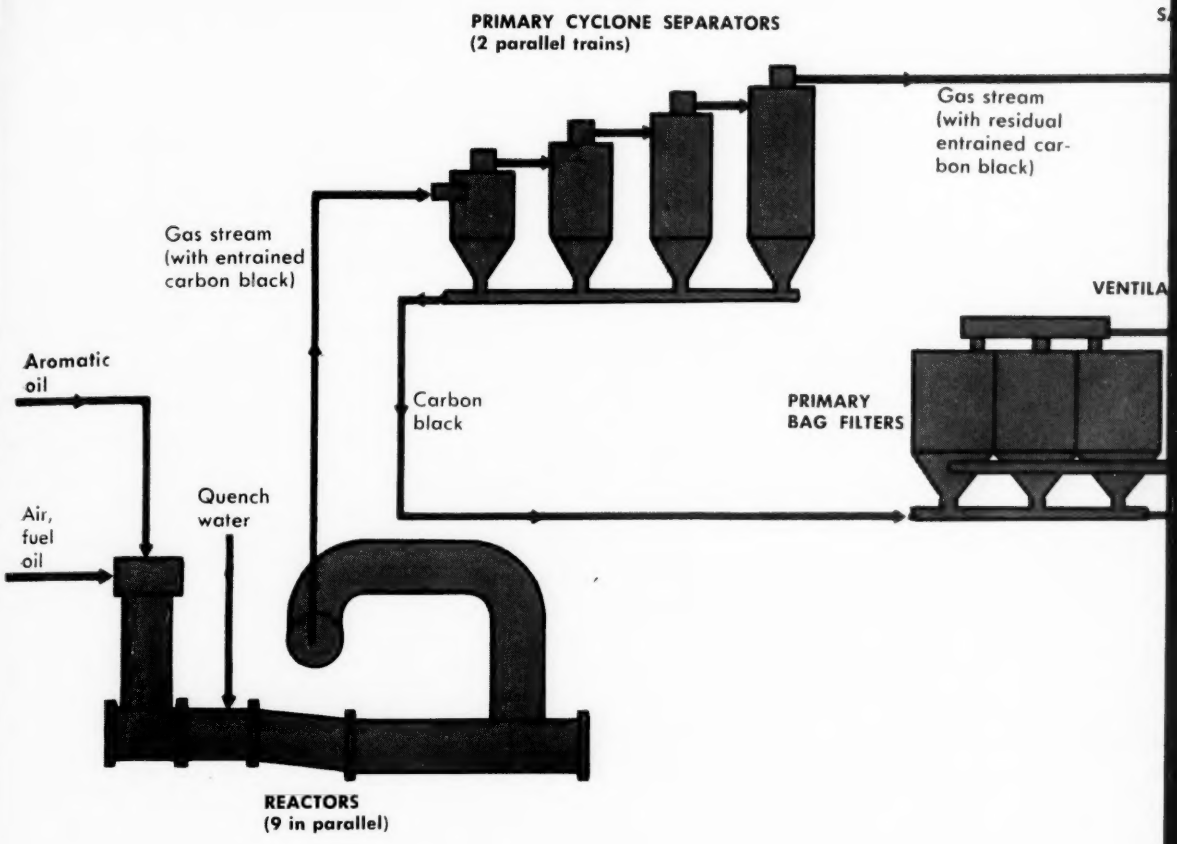
Typifying the booming rise of overseas capacity for making carbon black, a new plant of United Carbon France S.A. at Port Jerome, France, has lowered that country's import requirements for the material by some 50%.

The company, a subsidiary of United Carbon Co., Houston, went on stream with the facility in the early summer. It cost $5 million, can produce 50 million lb./yr.

The growth of carbon black (*Chem. Eng.*, June 26, p. 62) is due largely to rising capacity for making synthetic rubber. United Carbon's new plant fits well in this picture, because Port Jerome lies in the heart of France's rubber industry.

And, the facility is well situated for receiving its raw materials. It is the first plant in the European Common Market countries to make carbon black from fuel oil rather than from natural gas, and the former is readily available in the area. Esso Standard S.A.F., for instance, has a contract to supply United Carbon with 25,000 tons/yr. of an aromatic stock from Esso's nearby Port Jerome

Unfold flowsheet



refinery. An additional 25,000 tons of feedstock per year will be supplied by Compagnie Francaise de Raffinage.

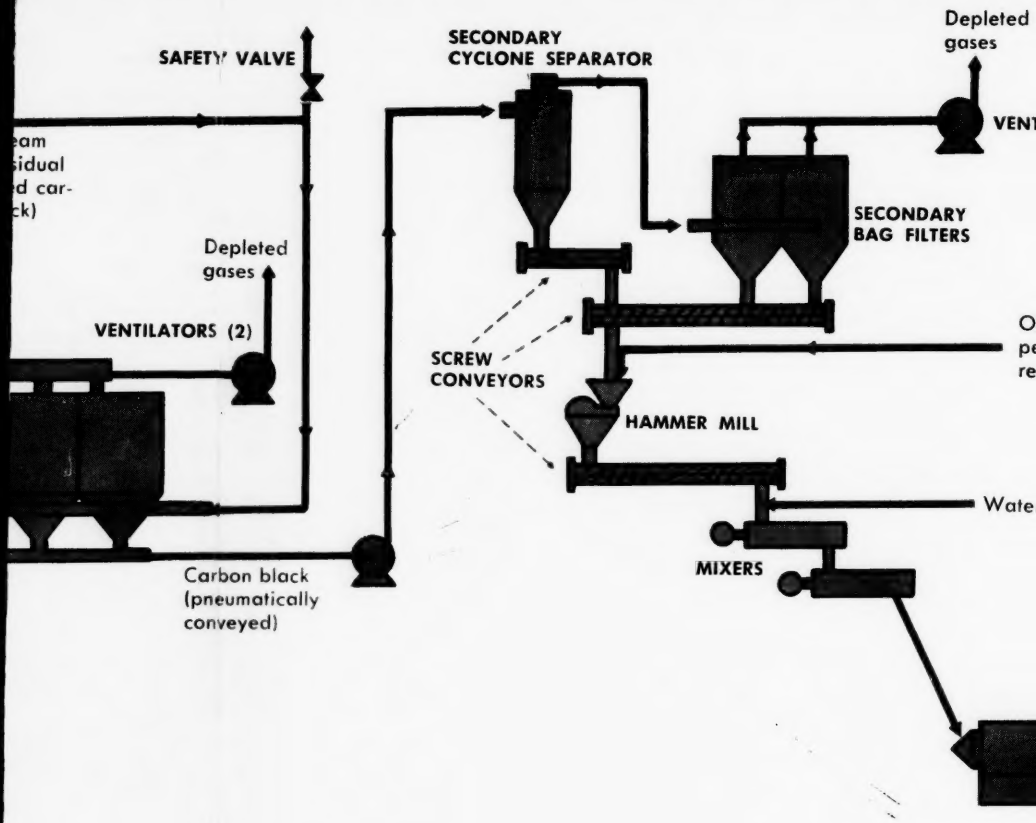
▶ **U.S., Too**—Carbon black's growth hasn't been confined to overseas. U.S. capacity is on the rise as well, with the spotlight currently on the West Coast: United Carbon itself will put a 64-million-lb./yr. plant on stream at Mojave, Calif., around the end of the year, and Continental Carbon Co. is already operating a new, 50-million-lb./yr. facility at Bakersfield, Calif. Industry observers see in these moves a significant step towards the West Coast's autonomy in tire production.

These plants, like the new one at Port Jerome, are designed to use the furnace process rather than the older, channel process. In the latter, natural gas is burned so that the flames impinge on a moving metal surface, from which the product is subsequently scraped. One big advantage of the furnace process is that the producer isn't limited to natural gas for his feedstock.

▶ **At Port Jerome**—Heart of the new plant is an array of nine reactors in parallel. Fuel oil is burned with an excess of air in the reactor combustion zones, generating a temperature of approximately 2,600 F. The aromatic feedstock is then sprayed into the combustion mass, where a portion of it burns with the excess air. The balance is thermally decomposed to carbon and hydrogen. Average temperature in the reactor zone is 2,900 F.

The reactor converts approximately 55% of the feed's carbon content to carbon black. The remainder passes through the process in the form of gaseous combustion products.

The plant produces three grades of carbon black: HAF (High Abrasion Furnace Black), ISAF (Intermediate Super Abrasion Furnace Black) and FEF (Fast Extrusion Furnace Black). Physically, these differ mainly in particle diameter and surface area. Process variables that are adjusted to produce the specific desired grade include operating temperature, space velocity in the reaction zone, and reactor geometry.



Fuel oil is reactor com- rature of ap- feedstock is lass, where a air. The bal- rbon and hy- reactor zone

ately 55% of black. The re- in the form

es of carbon rnace Black), sion Furnace rnace Black). article diame- bles that are ired grade in- velocity in the

The combustion gases carry the carbon black from the burners to quench areas in each reactor terminus, where a direct water spray lowers the stream temperature to about 1,000 F. After this, the mixture is ready for treatment that separates the product from the gases.

► **Separation**—Initial separation takes place in primary cyclones. For this step, there are two parallel trains of four cyclones each, which remove 85% of the carbon black contained in the gas stream. The latter goes next to a bag filter unit that takes out the remainder.

The bags in this unit are made of glass fabric. Each bag is 5½ in. in dia., 118 in. long. They are automatically cleaned every 15 minutes and have a continuous service life of 9 months or more.

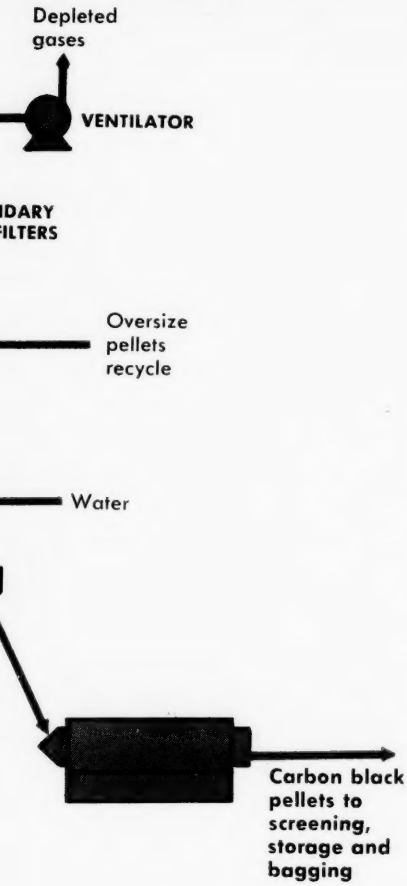
The gases pass through the filter unit at 400-450 F. After carbon black has been removed, the depleted stream exhausts to the atmosphere.

Carbon black removed in the cyclones and the bag filters is pneumatically conveyed to the finishing portion of the plant. Here the black is first separated in a smaller- tion system.

► **Finishing Up**—Screw separated product to a ha entering this equipment submicron size, and the verizer is not to make th rather to break up lump veyors. Also, it pulveriz lets that recycle from do

Pulverized material mately an equal weight with other, undisclosed li fed to "mixers," each of zontal housing containing on which pins are mounte causes the mixture to fo ticles, measuring $\frac{1}{16}$ to $\frac{1}{8}$

These pellets then g the water. Drying tempe pending on the product l are ready for screening, s



a smaller-scale secondary separa-

p—Screw conveyors transport the duct to a hammer mill. The particles equipment are already micron and e, and the main purpose of the pul- to make these particles smaller but ak up lumps that form in the con- it pulverizes oversize product pel- le from downstream screening.

d material is mixed with approxi- al weight of water (or occasionally disclosed liquids), and the stream is s," each of which comprises a hori- containing a revolving axial shaft are mounted. Agitation by the pins xture to form nearly spherical par- ng $\frac{1}{16}$ to $\frac{1}{8}$ in. in diameter.

lets then go to dryers that take out ying temperature is 375-450 F., de- e product load. Discharging pellets screening, storage and bagging.

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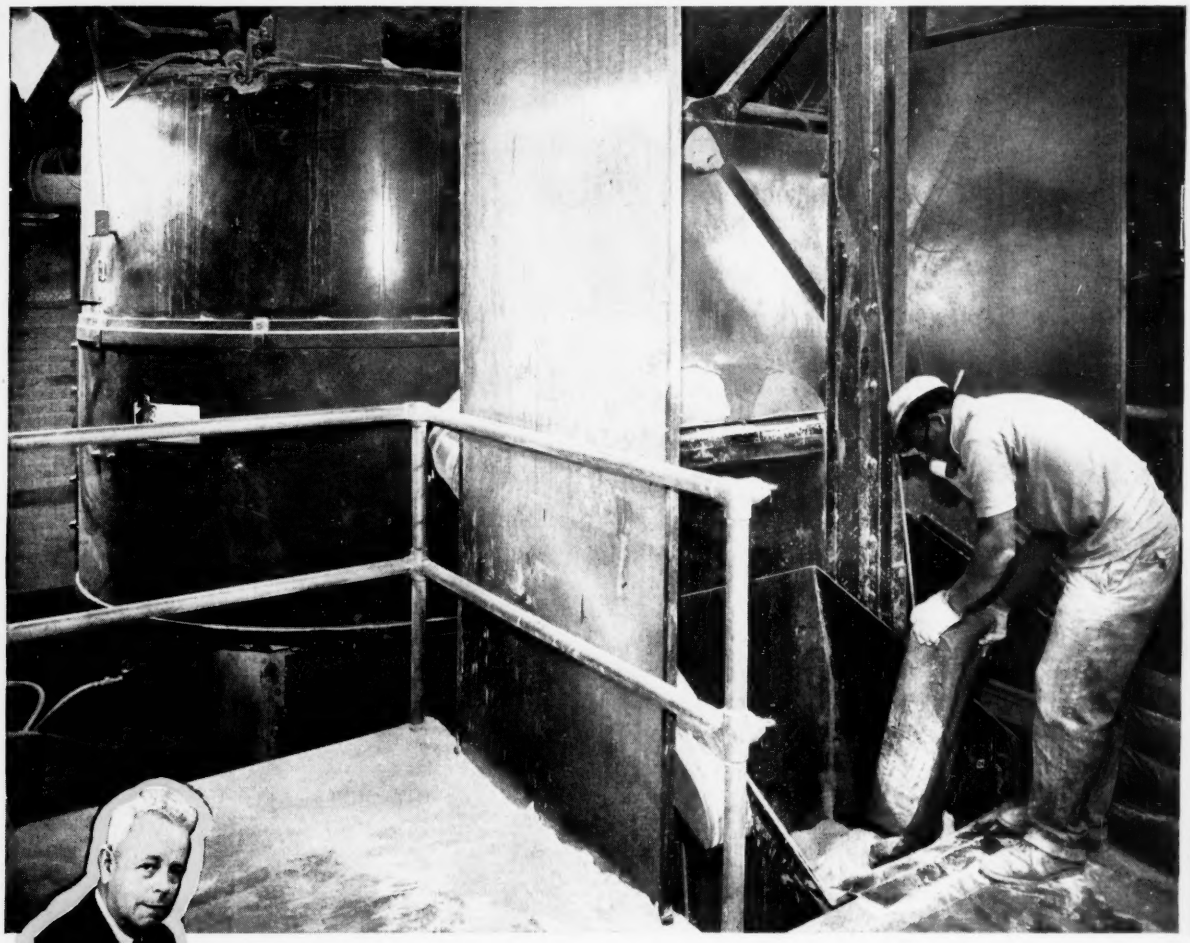

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. . . John C. Elder, Factory Manager, Robertson Manufacturing Company, Morrisville, Pennsylvania

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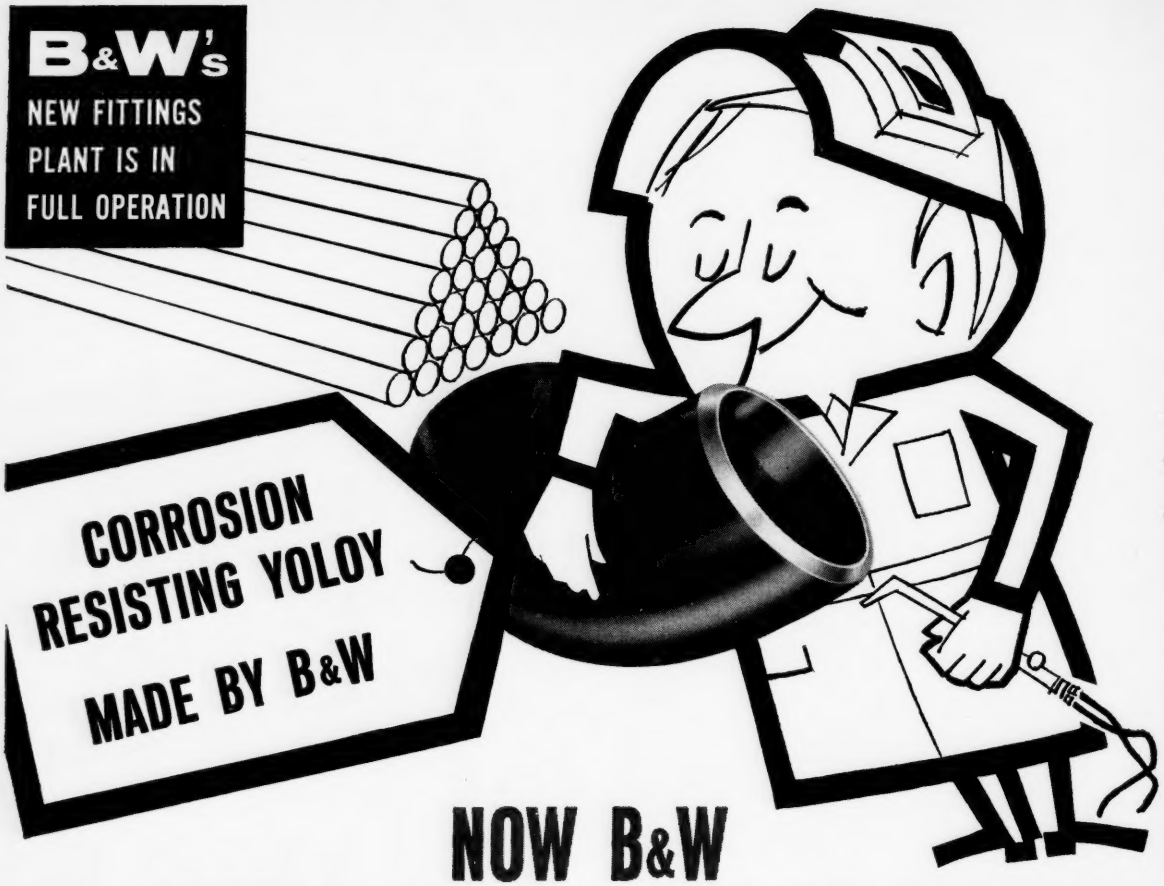

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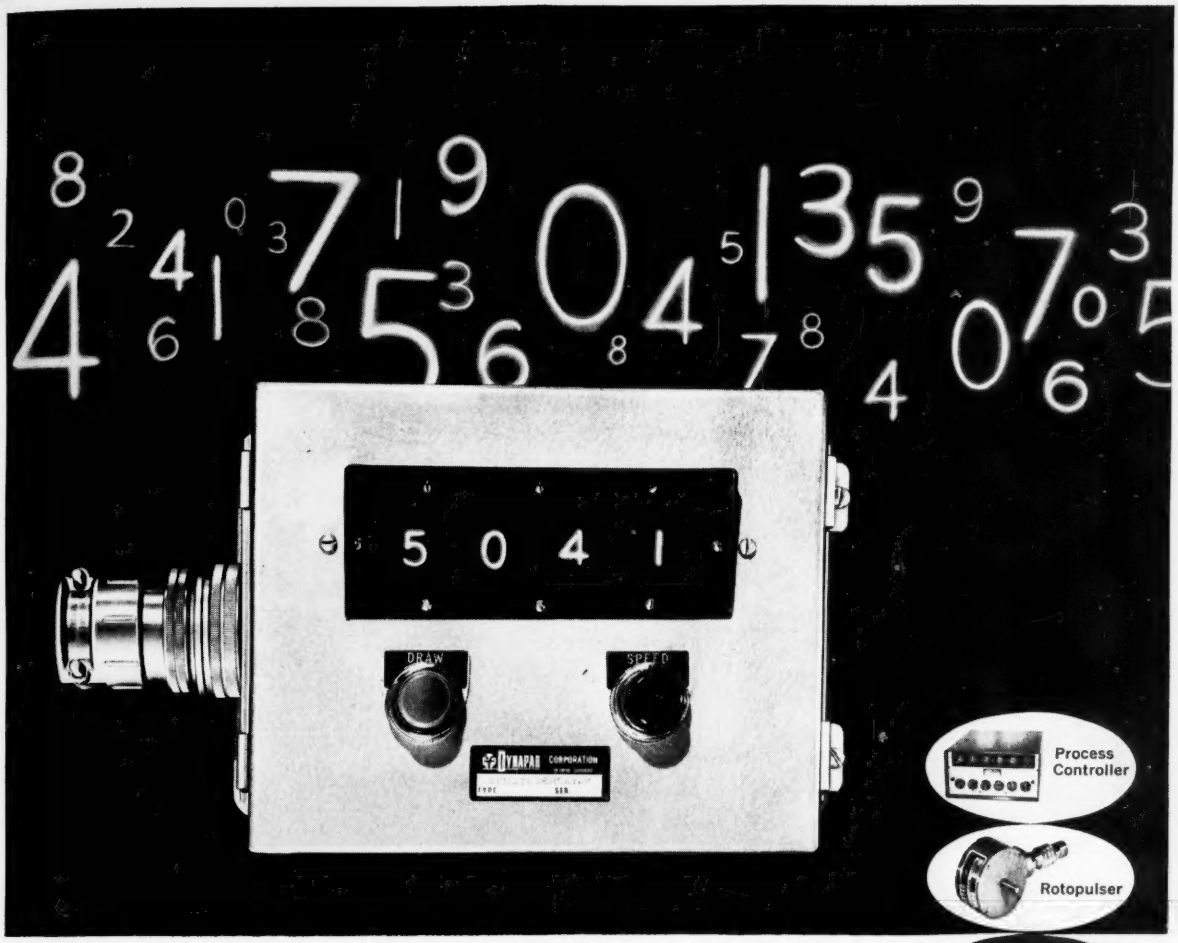

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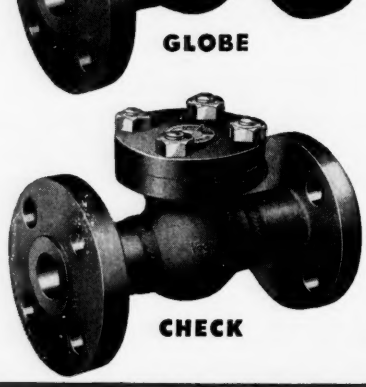

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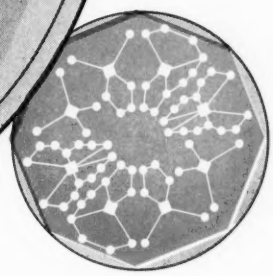
New Data on Metal-Complex Formation

Properties of metal ions can be modified or greatly altered by reaction with complexing agents. These ions and metal chelates can act as catalysts in chemical reactions, and chelating agents can control the activity of metal ions in aqueous solution.



ARTHUR E. MARTELL, *Illinois Institute of Technology*

During the past decade, a number of remarkable developments in the chemistry of coordination compounds have greatly changed and advanced the field of inorganic chemistry.

We are going to outline the main features and applications of one of these advances: the building up of a large body of data[1] on the interactions in aqueous solution of metal ions with a wide variety of organic compounds. We will also discuss the resulting refinement in our understanding of these chemical reactions and application to the control of metal ions.

Principles of complex formation will be used to show how properties of metal ions may be altered or modified by reacting them with complexing agents.

Metal Complexes and Chelates in Solution[2, 3]

Metal ions in aqueous solution behave as Lewis* acids and combine with weakly basic solvent molecules —producing coordination compounds, where electron pairs of the oxygen atoms are donated to the metal ion.

*A Lewis acid is defined as an electron-pair acceptor, a Lewis base is an electron-pair donor. This theory permits including materials in the acid-base system that do not contain hydrogen.

The nature of the hydrated ion varies, depending on the size, charge, and tendency of the metal ion toward covalent bond formation. The more basic metal ions, such as those of the alkali metal and larger alkaline earth ions, form loose associations with a variable number of water molecules having little or no structure. For these ions, one may assume distribution of forms in dynamic equilibrium. The ions of the less basic (more noble) metals have a greater tendency toward covalent bond formaton with electron-donor molecules, yielding stable hydrates in which water molecules are bound at fixed distances and in a definite geometric arrangement about a particular metal ion.

Such ions are characterized by a tendency to combine with a definite number of electron-donor atoms. This number, called the coordination number, increases with size and charge of the metal ion, and is somewhat dependent on geometric requirements resulting from directional tendencies of the metal ion for covalent bonding.

Rules of Coordination

Most metal ions have a coordination number of six;

so water molecules may be considered to be arranged more or less symmetrically at the corners of a regular octahedron, with the metal ion at the center. Ions of relatively high charge, such of those of Zr(IV), Hf(IV), U(IV), and Mo(VI), are known to have a coordination number of eight, while certain ions, such as those of Mg (II), Be (II), Cu (II) and Zn (II), are generally considered to have a coordination number of four in aqueous solution. Coordination rules do not always apply exactly, since some metal ions exist in more than one coordination state, but they serve as excellent guiding principles for many reactions of metal complexes.

A metal complex (Fig. 1a) can be defined as a coordination compound of a metal where one or more water molecules in the coordination sphere is replaced by another electron donor. These donors, called ligands, can be, for example, cyanide, ammonia, and organic bases. A metal chelate compound is a metal complex in which two or more ligands are bound together by chemical linkages (see Figs. 1b, 1c, 1d.).

Thus, a chelating ligand may be bidentate, terdentate, quadridentate, quinquidentate, or sexadentate, forming one, two, three, four or five chelate rings with the metal ion.

Formation Constants

A better understanding of the nature and chemical properties of metal chelates and complexes in solution has resulted from extensive quantitative equilibria studies involving their formation.[1, 4] Research activity in this area has resulted in publication of about 2,500 papers, involving about a thousand ligands and a wide variety of metal ions.

The quantity most frequently reported is the equilibrium constant, K_i, for the formation of the metal chelate or complex. Thus, for the complexes formed from a metal ion and a neutral ligand L:

$$M^{n+} + L \rightleftarrows ML^{n+} \quad K_1 = \frac{[ML^{n+}]}{[M^{n+}][L]}$$

$$ML^{n+} + L \rightleftarrows ML_2^{n+} \quad K_2 = \frac{[ML_2^{n+}]}{[ML^{n+1}][L]}$$

$$ML_{i-1}^{n+} + L \rightleftarrows ML_i^{n+} \quad K_i = \frac{[ML_i^{n+}]}{[ML_{i-1}^{n+}][L]}$$

Magnitudes of these equilibrium constants, usually called formation or stability constants, are usually taken as measures of solution stability. Of the wide variety of chelating ligands studied, those shown in Fig. 2 are common compounds that are generally readily available.

All the ligands shown above form stable, soluble complexes of metal ions, which are only very slightly dissociated. Such compounds have been given the name sequestering agents.

In the acid form, most of the coordinating groups in these ligands are bound to hydrogen ions, which must be displaced by the metal ion before a metal chelate can be formed. Thus, in the case of ethylenediaminetetraacetic acid (EDTA), H_4L, with four displaceable protons, the aqueous equilibria may be expressed by the following equations:

$$\begin{array}{rl} \text{pH} < 3 & M^{n+} + H_4L \rightleftarrows ML^{n-4} + 4H^+ \\ 4 < \text{pH} < 6 & M^{n+} + H_2L^{2-} \rightleftarrows ML^{n-4} + 2H^+ \\ 7 < \text{pH} < 9 & M^{n+} + HL^{3-} \rightleftarrows ML^{n-4} + H^+ \\ 10 < \text{pH} & M^{n+} + L^{4-} \rightleftarrows ML^{n-4} \end{array}$$

The pH ranges correspond to ranges of stability of the various protonated anions of the ligand. Thus, competition with hydrogen ions becomes less important as the pH is raised.

Special Properties of Metal Chelates

As a result of stability measurements that have become available, the special properties of chelate compounds are now fairly well understood. It is interesting that the principles involved turn out to be simply the application of thermodynamics to chemical species in solution, as will be shown below:

1. The Chelate Effect[3]

Since iminodiacetic acid (IMDA) has two acetate groups and one nitrogen group, two moles of this ligand may be considered equivalent to one mole of EDTA. The resulting metal chelates would differ only in the ethylene bridge, which would contribute an additional (central) ring to the EDTA chelate. Thus, a comparison of the equilibrium constants for the combination of a metal ion with two moles of IMDA and one mole of EDTA would give the stability

Additional ring produces more stable chelates–Table I*

Metal Ion	Log K_{MA_2}**	Log K_{MB}**	Log K_{MB} – log K_{MA_2}
Ca(II)	5.4	10.6	5.2
Fe(II)	10.1	14.0	3.9
Zn(II)	12.2	16.0	3.8
Co(II)	12.3	16.2	3.9
Ni(II)	14.6	18.2	3.6
Cu(II)	16.1	18.5	2.4

*Stability increments of metal chelates resulting from substitution of two moles of iminodiacetate by one mole of ethylenediaminetetraacetate.
**A, iminodiacetate; B, ethylenediaminetetraacetate; K, stability constant; M, metal ion.

Larger chelate rings are less stable–Table II*

Carbon Atoms in Ethylene Bridge**	Log K			
	Mg(II)	Ca(II)	Sr(II)	Ba(II)
2	8.7	10.5	8.6	7.8
3	6.0	7.1	5.2	4.2
4		5.0		
5		4.6		

*Formation constants of alkaline-earth chelates of homologs of ethylenediaminetetraacetic acid.
**Numbers give values of n in Fig. 3.

difference for the addition of one chelate ring (two chelate rings for each IMDA vs. five chelate rings for EDTA). Such comparisons for a series of metal ions in Table I show that the chelates with the additional ring have greater stability by a factor of over 10^2 (see p. 96).

The increase of stability resulting from chelate-ring formation is very sensitive to size of the ring formed—the smaller ring corresponding to higher stability. In practice, this works out so that 5-membered rings are generally the most stable.

Smaller rings of the type shown in Fig. 1 cannot be formed from polydentate organic ligands for steric reasons. But larger rings, such as are formed from the EDTA homologs listed in Table II, are considerably less stable. As indicated by Fig. 3, increasing the bridge between the nitrogen atoms of EDTA from two to five carbon atoms increases size of the central metal chelate ring from five to eight atoms. The resulting remarkable decrease in stability corresponds to a decrease in the probability of forming a complex from the free ligand.

Why Chelates Are Stable

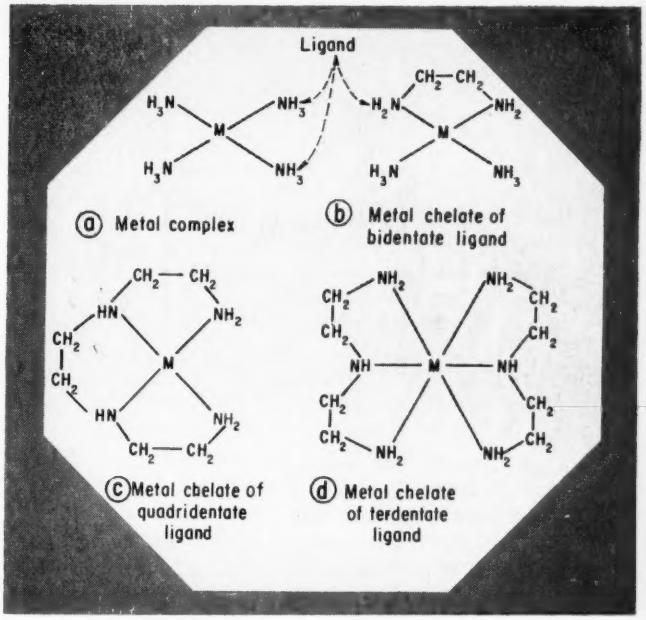
The greater stability of the chelate over that of an otherwise analogous complex is due to differences in the loss of translational entropy on formation of the coordination compounds in solution. Equilibrium constant of the chelate is larger, since standard states of the reacting species are taken as one molal solution of the fully hydrated ions and molecules.

This point is more easily understood by looking at a hypothetical set of examples shown in Table II (see p. 96).

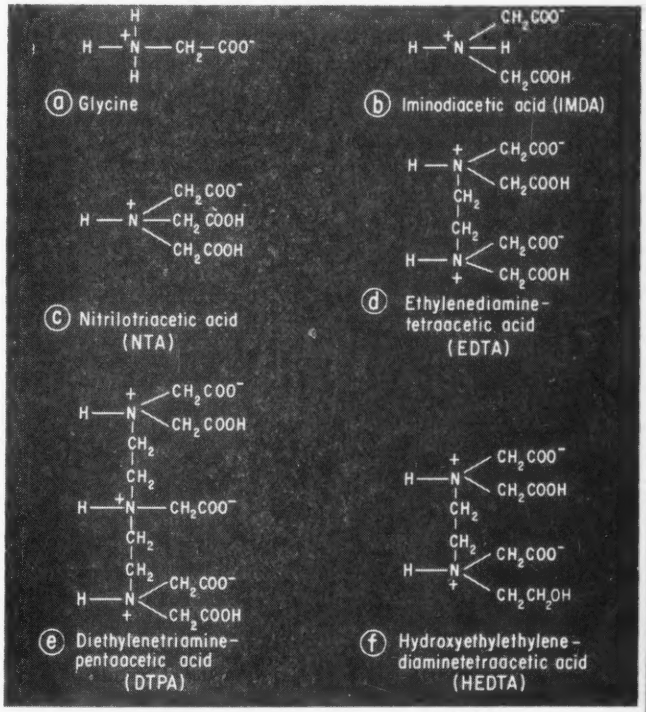
Assume that all A groups of the ligands have equivalent affinity for the metal ion: total energy of coordinate bond formation, which is reflected in the heat of reaction ΔH, will be the same for all three complex models. Since the stability constant K is directly related to the free-energy change associated with complex formation, it is necessary to take into account entropy changes as well as enthalpy effects. Thus, for the examples given in Table III, any differences in the stability constants of metal complexes and chelates must be found in differences in the entropy terms.

For reactions in solution, the standard state of unit molality requires that all solute species contain considerable translational entropy (about 7.9 entropy units per mole). In forming the metal chelate from the metal ion and a quadridentate ligand, two particles combine to give a single particle, resulting in a loss of 7.9 units of translational entropy of solution. For the metal chelate $M(A\text{-}A)_2$, the decrease in the number of particles is two, resulting in a loss of 15.8 entropy units. Thus, formation of the complex MA_4 and the chelate $M(A\text{-}A)_2$, should be 23.7 and 7.9 entropy less favorable than the formation of the more completely chelated structure, M (A-A-A-A). On this basis, the stability constant of the chelate compound having two chelate rings should be about

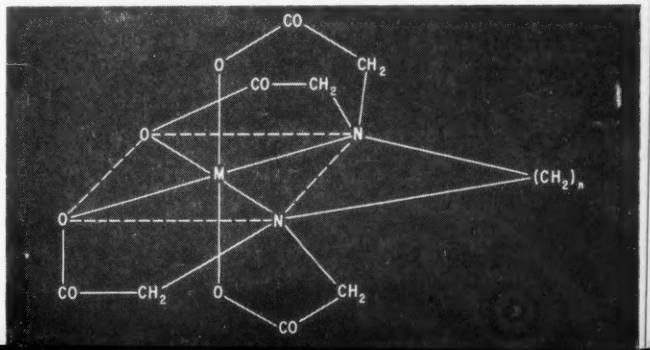
Metal chelates contain linked ligands—Fig. 1


Ligand
(a) Metal complex
(b) Metal chelate of bidentate ligand
(c) Metal chelate of quadridentate ligand
(d) Metal chelate of terdentate ligand

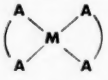
These ligands form stable, soluble complexes—Fig. 2



Increasing ring size decreases stability—Fig. 3



Dilution effects for complexes with different number of chelate rings –Table III

Reaction	Number of Chelate Rings	Stability Constants Formation	Value* of K	Free $[M^{n+}]$ for 10^{-3} M Complex
$M^{n+} + 4A \rightleftharpoons MA_4^{n+}$	0	$\frac{[MA_4^{n+}]}{[M^{n+}][A]^4}$	10^{18}	1×10^{-4}
$M^{n+} + 2A\text{-}A \rightleftharpoons$ 	2	$\frac{[M(A\cdot A)_2^{n+}]}{[M^{n+}][A\cdot A]^2}$	10^{22}	5×10^{-9}
$M^{n+} + A\text{-}A\text{-}A\text{-}A \rightleftharpoons$	3	$\frac{[M(A\cdot A\cdot A\cdot A)^{n+}]}{[M^{n+}][A\cdot A\cdot A\cdot A]}$	10^{24}	3×10^{-14}

*Assuming $\triangle H^\circ$ the same for all complexes, no steric effects, and an arbitrary value of 10^{24} for the stability constant of the metal chelate. Letter A denotes groups of the ligands.

4 log *K* units, and that having three rings about 6 log *K* units, higher than that of the analogous complex having no chelate rings.

Magnitude of the equilibrium constant is based on thermodynamic changes occurring for solutes in their standard states—therefore, it does not reflect the relatively great importance of the effect of entropy of dilution on reactions in very dilute solutions. A comparison is readily made, however, by calculating the degree of dissociation at a lower concentration, as is done in Table III for 10^{-3} M. concentration of metal complexes and chelates. These relatively crude calculations show that the complex with no chelate rings would be over a billion times more dissociated than the analogous compound with three chelate rings.

Alternatively, one can also state that much of this difference in stability would disappear for solutes in relatively concentrated solutions, and would be lost altogether for reactions between pure substances.

2. How Charge Neutralization Affects Chelates

The very high stability constant values of chelates involving ethylenediaminetetraacetic acid and similar ligands cannot be accounted for on the basis of merely the entropy increase predicted by the chelate effect.

In the combination of positive and negative ions in aqueous solution, there is always a considerable increase in entropy that results from a reduction in the number of water molecules of hydration "frozen" around each center of charge. The water molecules around each ion are under considerable restraint. This contributes to a negative value of the entropy of the solvated ion. These entropy values become more negative as the charge increases and as the ionic radius decreases.

When two ions combine, the reaction that occurs may be represented as follows:

$$M(H_2O)_x^{n+} + L(H_2O)_y^{m-} \rightarrow ML(H_2O)_z^{n-m} + (x + y - z)H_2O$$

where: $x + y > z$; L is ligand; M is metal ion.

Thus, reduction in charge is accompanied by release of water of hydration and consequent increase in entropy. This phenomenon may account for a large part, perhaps a major part, of the entropy increase occurring in the formation of EDTA chelates given in Table IV.

From the heats and entropies listed in Table IV, it is seen that almost all the stability is found in the entropy change, with only a small contribution to $-\Delta F$ from the heat of reaction, in the case of the alkaline earth ions. This means that the covalent character of the coordinate bonds of the metal ion in the chelate is no greater than in the free hydrated ion. Other examples in Table IV indicate that the metal ions become more electro-negative there is an increase in ΔH, corresponding to an increase in covalent character of the coordinate bonds.

Further thermodynamic studies have been carried out with related ligands in which the number of negative groups of the ligand that combine with the metal ion were systematically changed. It was found that the entropy change occurring on complex formation follows the number of negative groups that combine with the metal ion (i.e., follows the neutralization of charge resulting from complex formation).

Factors For Forming Stable Chelates

From the examples given above, it is seen that stability of a metal chelate is enhanced by the following factors:

- Increase in the number of chelate rings (stability further enhanced in dilute solution).
- Decrease in length of the chemical linkage between donor groups of the ligand.
- Increase in rigidity of the chemical linkage between donor groups of the ligand.
- Increase in number of negative groups of the ligand that combine directly with the metal ion.
- Decrease in size of the metal ion (corresponding to increased entropy effect of release of water molecules on charge neutralization).
- Increase in charge of the metal ion.
- Increase in coordination number of metal ion (to allow combination with a larger number of donor groups of the ligand that may be available).

Influence of the Metal Ion

It is not possible, within the limited space available, to state very much about variation of stability with nature of the metal ion in the complex.

The way in which the radius and charge of the ion affects the stability has been mentioned above. In metal complexes having considerable covalent char-

Heats and entropies of combination: EDTA with divalent metal ions—Table IV

Metal Ion	Heat, ΔH° Kcal./Mole	Entropy, ΔS° Cal./°C.
Mg(II)	− 3	+32
Ca(II)	− 3	+42
Sr(II)	− 4	+26
Ba(II)	− 4	+22
Mn(II)	− 5.2	+41
Co(II)	− 4.1	+58
Ni(II)	− 7.6	+55
Cu(II)	− 8.2	+55
Zn(II)	− 4.5	+55
Cd(II)	− 9 1	+38
Pb(II)	−13.1	+35

acter, there are many other factors, involving variation of electronegativity, angular dependence of electron distribution about the metal ion, and steric requirements of both the metal ion and the ligand. These subjects have been described elsewhere.[5]

Variation of the type usually observed for the first-row transition metal ions is illustrated in Fig. 4. As the atomic number of the bivalent ions increases through the series, the stabilities increase to a maximum value for Cu(II), followed by a drop for Zn(II). The dotted line, which illustrates variation of ionization potential for the same elements, follows the stability function quite well. In fact, the ionization potential sum serves as an excellent correlating function, as may be seen in Fig. 5.

How to Obtain Specificity and Selectivity

Two important objectives of coordination chemists and analytical chemists are preparation of ligands that (1) selectively complex one metal ion over another as an aid in their separation, (2) or repress the chemical activity of undesirable metal ions while leaving unaffected others present in the same solution.

As shown in the data in Fig. 4, merely increasing the absolute stability of a series of metal complexes does not increase selectivity, since the latter function depends on differences in stability between one or more pairs of metal ions. Since the chelate effect and other entropy effects described would be expected to differ very little for many metal ions, one must look for selectivity in differences toward covalent binding, which is reflected in the enthalpy of coordination between a metal ion and a ligand.

Although it is not possible to make a detailed analysis of how selectivity has been achieved by changing the nature of the donor group coordinated to the metal ion, the following example illustrates the principles involved.

A Selective Reagent for Fe (III)—Many compounds have been synthesized in the search for better compounds for binding Fe(III) ions, since the stability of Fe(III)-EDTA chelate is not high enough to keep it from decomposing and precipitating as ferric hydroxide above pH 8-9.

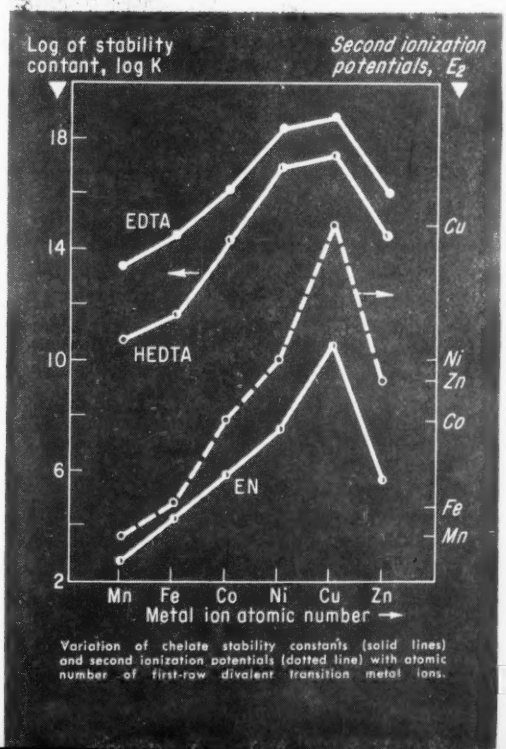
Effect of increasing the pH of the solution on this complex is indicated by the reactions shown in Fig. 6. Some of the carboxyl groups of Fig. 6a are either loosely bound or not bound at all, so one or more of them may be replaced by hydroxyl groups at high pH. As the pH is raised further, the process continues, so that above pH 8, ferric hydroxide may eventually precipitate.

In the search for more effective chelating agents, it was found that, while the Fe(III) complexes of hydroxyethylethylenediaminetetraacetic acid (Fig. 2f) and of diethylenetriaminepentaacetic acid (Fig. 2e) are stable to somewhat higher pH values, they also decompose to ferric hydroxide in solutions that are only moderately alkaline.

A compound recently found to have such a high affinity for iron that its Fe(III) chelate does not decompose, even in the most strongly alkaline solutions, is N,N'-ethylenebis[2-(o-hydroxyphenyl)] glycine (Fig. 7a). In this compound, two of the carboxylate groups of EDTA may be said to be replaced by phenolic groups (although there is, of course, a further difference in the steric arrangements of these). Since aromatic hydroxyl groups are known to have high affinity for Fe(III), it is perhaps not surprising to find that EHPG has very high affinity for Fe(III), and relatively low affinity for many other metal ions.

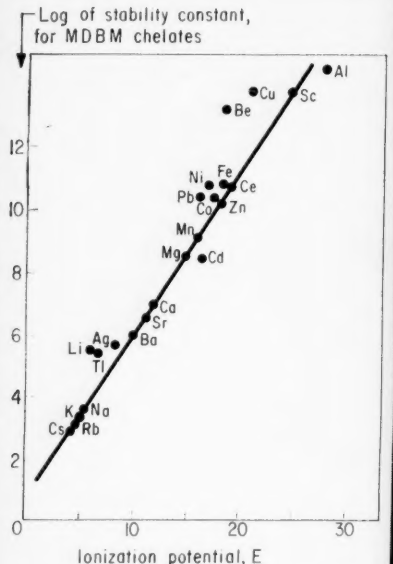
Stabilities of the chelates of this ligand with a few

Effect of atomic number—Fig. 4



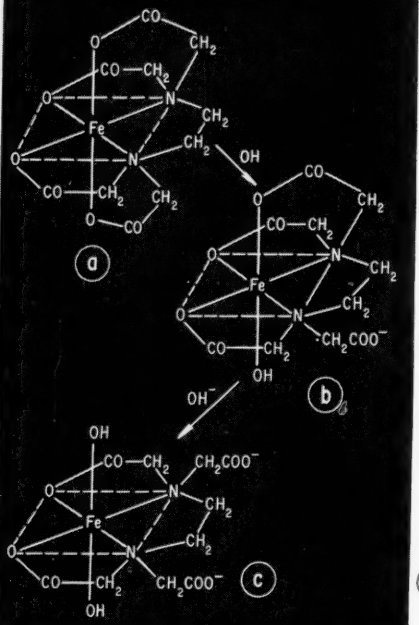
Variation of chelate stability constants (solid lines) and second ionization potentials (dotted line) with atomic number of first-row divalent transition metal ions.

Ionization potential is a measure of stability—Fig. 5

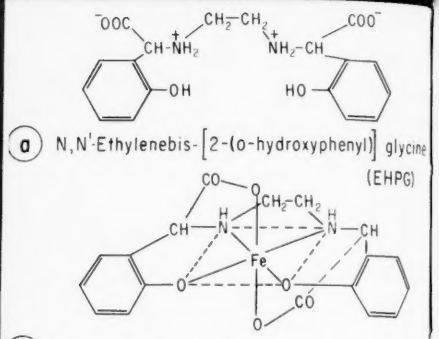


Variation of stability constants of monodibenzoylmethane chelates with ionization potential sums of the gaseous metal ions.

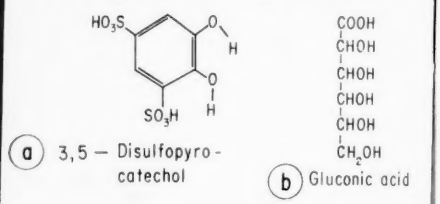
High pH attacks iron chelate—Fig. 6



A very stable iron-chelate compound—Fig. 7



Compounds with strong iron linkages—Fig. 8



metal ions are given in Table V, and a proposed structure of the iron (III) chelate is illustrated in Fig. 7b. The formation constant of 10^{35} given for this chelate is the highest ever measured for a labile complex in aqueous solution.

Thus, if relative affinities of specific donor groups for various metal ions are known, it should be possible to conceive of and synthesize ligands that would best satisfy certain coordination tendencies. In this way, it is possible to prepare highly selective reagents for metal binding. There are already many instances where this has been done, particularly where the separation, identification and measurement of metal ions in solution has been an important and fundamental problem.

Two examples of additional chelating agents (sequestering agents) that are effective in the binding of iron as a stable soluble complex at high pH are 3, 5-disulfopyrocatechol (Fig. 8a) and gluconic acid (Fig. 8b). Many similar reagents are known that can be used to keep metal ions in solution under conditions that would ordinarily result in metal precipitation.

Metal-Ion Buffers

The wide variety of ligands for which metal-chelate formation constants are now known makes it possible to control metal ions in aqueous solution, just as it is possible to control hydrogen-ion concentration by means of bases that bind hydrogen ions strongly.

Applications of coordination compounds for controlling metal ions is usually described in terms of pM, the negative logarithm of the metal ion concentration—a quantity exactly analogous to pH.

Hydrogen-ion buffer:

$$HA \rightleftarrows H^+ + A^- \quad [H^+] = K_a \frac{[HA]}{[A^-]}$$

$$pH = -\log [H^+] = pK_a + \log \frac{[A^-]}{[HA]}$$

Metal ion buffer:

$$M^{n+} + L^{m-} \rightleftarrows ML^{n-m} \quad [M^{n+}] = K_1^{-1} \frac{[ML^{n-m}]}{[L^{m-}]}$$

$$pM = -\log [M^{n+}] = \log K_1 + \log \frac{[L^{m-}]}{[ML^{n-m}]}$$

By varying the ratios of ligand, L^{m-}, and metal chelate, ML^{n-m}, it is possible to set up a buffer system for control of the metal-ion concentration over a range of pM values. With a wide variety of ligands to choose from, the value of log K_1 can be varied over a very wide range, so that almost any reasonable value of pM may be obtained.

Ligands basic enough to bind metal ions strongly also bind hydrogen ions, so there is nearly always some degree of competition between hydrogen ions and metal ions, and pH must be controlled if pM is to be kept relatively constant.

Interaction of the ligand with hydrogen ions results in greater dissociation (lower pM) of the metal ion at low pH, to an extent dependent on the dissocia-

tion constants of the ligand, and the number of protons bound per ligand anion or molecule. A familiar example is EDTA, which exists in the diprotonated form in the pH range 4 to 6, is monoprotonated from pH 7 to 9; and is completely dissociated above pH 10. The equilibria with the Cu(II) ion may be explained as follows:

For $4 < pH < 6$

$$Cu^{2+} + H_2L^{2-} \rightleftarrows CuL^{2-} + 2H^+$$

$$K_{eq.} = \frac{[CuL^{2-}][H^+]^2}{[Cu^{2+}][H_2L^{2-}]} = 10^2$$

$$pCu = 2 + \log \frac{[H_2L^{2-}]}{[CuL^{2-}]} + 2pH$$

For $7 < pH < 9$

$$Cu^{2+} + HL^{3-} \rightleftarrows CuL^{2-} + H^+$$

$$K_{eq.} = \frac{[CuL^{2-}][H^+]}{[Cu^{2+}][HL^{3-}]} = 10^3$$

$$pCu = 8 + \log \frac{[HL^{3-}]}{[CuL^{2-}]} + pH$$

For $10 < pH$

$$Cu^{2+} + L^{4-} \rightleftarrows CuL^{2-}$$

$$K_{eq.} = \frac{[CuL^{2-}]}{[Cu^{2+}][L^{4-}]} = 10^{18}$$

$$pCu = 18 + \log \frac{[L^{4-}]}{[CuL^{2-}]}$$

Stability constants for EHPG*—Table V

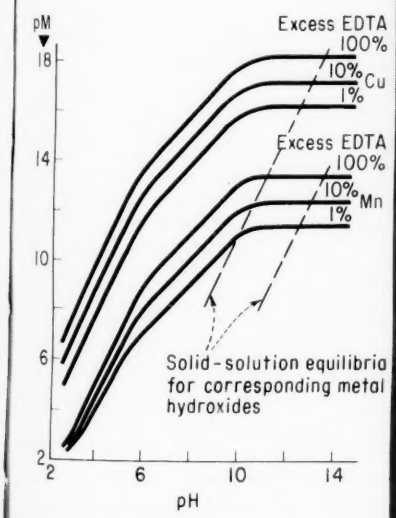
Metal Ion	Log K_{MH_2L}	Log K_{MHL}	Log K_{ML}
Cu(II)	>15	>20	>24
Ni(II)	11.4	15.6	19.7
Zn(II)	9.3	12.9	16.9
Cd(II)	7.8	10.1	13.1
Mg(II)	2.9	5.2	8.0
Ca(II)	1.7	4.8	7.2
Fe(III)	–	–	~35

*N, N'-ethylenebis[2—(o—hydroxyphenyl)] glycine.

How pH Affects Metal Ions

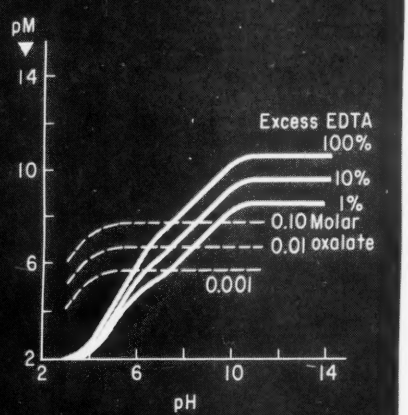
The behavior described by the relationships given above is illustrated in Fig. 9, which shows how pCu varies with pH for various ratios of ligand to metal chelate. As pH increases, pM also increases, finally becoming independent of pH in the region above pH 10 where the ligand is fully dissociated. The pM-pH relationship is seen to be the same for Mn(II), except that the absolute values of pM attained are considerably less, because Mn(II) is generally less strongly coordinated than Cu(II).

pH-control stabilizes metal concentration—Fig. 9



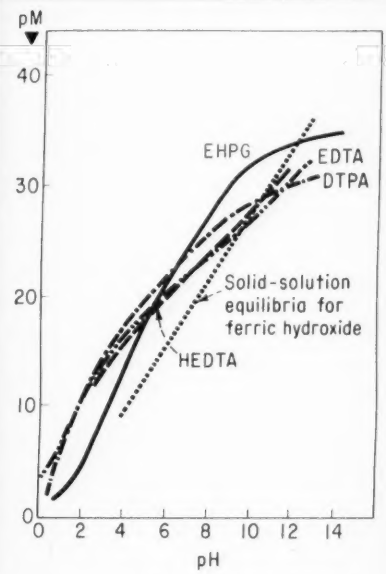
pM vs. pH for Cu (II) and Mn(II) EDTA chelates. Curves represent % of free ligand species in excess of amount needed to form metal chelate. Dotted lines show solid-solution equilibria for metal hydroxides.

Precipitates form at critical pH—Fig. 10



pM vs. pH for Ca(II)—EDTA chelates in presence of 1, 10 and 100% excess free ligand. Dotted lines indicate solid-solution equilibria of calcium oxalate in presence of varying concentrations of free oxalate ion.

Common chelates not good at high pH—Fig. 11



pM vs. pH for various Fe(III) chelates in the presence of an equivalent amount of unbound ligand. Dotted line represents solid-solution equilibria for ferric hydroxide.

Applications of sequestering agents—Table VI

Process or Product	Ligands Employed*	Metal Ions Sequestered
Metal cleaning	EDTA, NTA, DTPA, condensed phosphates	Fe, Cu, hard water salts
	Citric acid, oxalic acid, tartaric acid	Fe, surface deposits
	Gluconates, citrates	Fe, divalent metals, Al, Cr
Separation of metals	EDTA, NTA, DTPA	Rare earths
	EDTA, aspartate	Heavy metals
Metal plating	Cyanide, gluconate, tartrate, polyamines	Cu, Cd
	Citrate, oxalate	Fe, Pb, Cu-Zn
Emulsion polymerization	EDTA, NTA, DTPA	Fe(II)-Fe(III), divalent heavy metals
Leather tanning	EDTA, oxalic acid	Ca, Cr, Fe
	Gluconate	Fe
	Gluconate	Al, Ti
Food processing	EDTA	Ca
	EDTA	Heavy metals
	EDTA	Alkaline earths
Germicides, algaecides, herbicides	EDTA, polyphosphates	Ca, Mg, Fe
Metal dyes	EDTA, DPTA	Fe, Cu, Ni, hard-water salts
Pulp and paper	EDTA, Polyphosphates	Heavy metals
Stabilization of various substances		
Vegetable oils	EDTA	Heavy metals
Formaldehyde	EDTA, citrate	Heavy metals
Hydrazine	EDTA, pyrophosphate polyamines	Cu. V, and other transition metals
Polvinylchloride	EDTA	Heavy metals
Soaps	EDTA, NTA	Heavy metals
Frozen fruits	Citric acid	Cu, Fe
Cellulose esters	EDTA	Heavy metals
Rubber	EDTA, NTA	Cu, W, Co, Mn, Fe

* See p. 96 for description of ligands.

As pH of an aqueous solution containing a metal ion increases, solubility of the metal hydroxide decreases, resulting in precipitation of the solid hydroxide when the solubility product, $K_{sp.}$, of the metal hydroxide is exceeded:

$$M^{2+} + 2OH^- \rightleftarrows M(OH)_2 \text{ (solid)}$$
$$K_{sp.} = [M^{2+}][OH^-]^2$$
$$pM = -\log [M^{2+}] = \log (K_w K_{sp.}^{-1}) + 2pH$$

From the data in Fig. 9, it is seen that EDTA binds Cu(II) and Mn(II) ions strongly enough to prevent their precipitation as the hydroxide, up to a pH of about 12; above 12, precipitation would be expected to occur. Thus, competition between metal-ion hydrolysis and complex formation is such that it becomes increasingly difficult to prevent precipitation of the hydroxide as the pH is increased to very high values.

When precipitation occurs through formation of an insoluble salt of the metal ion with some anion that may be present in the solution, the increasing stability of the chelate with increasing pH frequently results in a situation where the metal ion does not precipitate at high pH, but only when the hydrogen-ion concentration is above a critical value. This is indicated in Fig. 10 for calcium oxalate precipitation in the presence of EDTA. This behavior is the type usually observed when the precipitating anion does not bind hydrogen ions strongly; when it does, the relationships are more complex.

In the case of a metal chelate such as that formed from Fe(III) and EDTA ions, the metal buffer curves do not flatten out because of partial hydrolysis of the metal chelate described above. The resultant further binding of the metal ion with hydroxyl ions imparts a measure of additional stability at higher pH—this, however, may be lost if the partially hydrolyzed complex is readily converted to the metal hydroxide, as frequently happens. The difficulty of obtaining a complex of Fe(III) that does not undergo such hydrolysis can be seen from the curves illustrated in Fig. 11. Here, it is seen that the common chelating agents such as EDTA, HEDTA, and DTPA are the most effective for the binding of Fe(III) ions at low pH, but only the special EHPG ligand is stable toward ferric hydroxide precipitation at very high pH.

Effect Produced
Scale removed (neutral solution)
Acid cleaning, pickling of iron (inhibitors added)
Alkaline cleaning (free caustic present), aluminum etching
Elution of ion-exchange columns
Gangue depressors in ore flotation
Plating of pure metals and combinations of metals
Synthetic rubber recipe containing polyamines
Cleaning, stripping and removal of stains
Iron tanning
White tanning
Blood anti-coagulant
Prevents discoloration of crustaceans in cooking
Clarifies wines
Prevents precipitation of active agent by metal
Prevents interference by metal impurities
Slows down metal-catalyzed oxidation
Prevents metal-catalyzed auto-oxidation
Prevents metal-catalyzed auto-oxidation
Prevents metal-catalyzed auto-oxidation
Color stabilization
Prevents oxidative rancidity
Retards oxidation of ascorbic acid
Retards oxidation
Antioxidant

Oxidation Potentials

Since, as we have seen, affinity of a ligand for a metal ion increases with charge of the ion, presence of a ligand will generally tend to increase the oxidation potential of a metal (it will increase its tendency to be oxidized to the higher valence state).

The major exceptions to this generalization are cases where the ligand favors highly covalent coordinate bonds of a type or arrangement that are better satisfied by the metal ion in its lower valence state. However, there is a general rule for labile complexes that quickly form or dissociate in aqueous solution: increasing oxidation potential as a direct function of the logarithm of the difference in stability constants of metal chelates in the higher and lower valence states.

The table (right) gives a few examples of how the oxidation potential of the Fe(II)/Fe(III) couple varies as a function of the ligands.

It is seen that the iron-complex systems given above, arranged in the order of increasing stability, have oxidation potentials that increase in the same order.

Reaction*	E^0, Volts
$Fe(H_2O)_x^{2+} \rightarrow Fe(H_2O)_x^{3+}$	−0.77
$FeAc^{1+} \rightarrow FeAc^{2+}$	−0.57
$FeCit^{1-} \rightarrow FeCit^{0}$	−0.22
$FeSal^{0} \rightarrow FeSal^{1+}$	−0.20
$FeEDTA^{2-} \rightarrow FeEDTA^{1-}$	−0.12

Catalytic Effects of Metal Ions

Metals may function as catalysts for chemical reactions in aqueous solution in two ways: by polarizing a molecule through its function as a Lewis acid; by initiation of an oxidation-reduction reaction through removal of the metal ion from the donor groups of a ligand.

1. Acid-Base Catalysis

Although metal ions are weak Lewis acids, they are effective as catalysts because they have a number of properties not possessed by the proton or hydronium ion.

Thus, steric requirements, as well as ability of metal ions to coordinate with more than one position of an organic ligand, plus their ability to function in solutions at low hydrogen ion but high hydroxyl ion concentrations offer advantages in certain reactions. For these reasons, many metal ions and complexes function as catalysts in biological systems. Metal ions have also been found to be catalysts for many simple chemical reactions such as hydrolysis of esters.

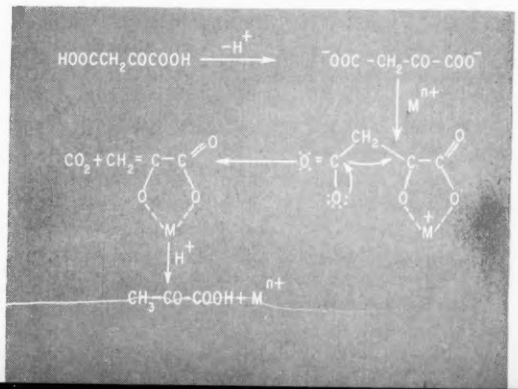
Fig. 12 is an example of simple acid-base catalysts involving a metal ion in the decarboxylation of an organic acid. Research is beginning to reveal other interesting reactions of this type.

2. Redox Catalysis

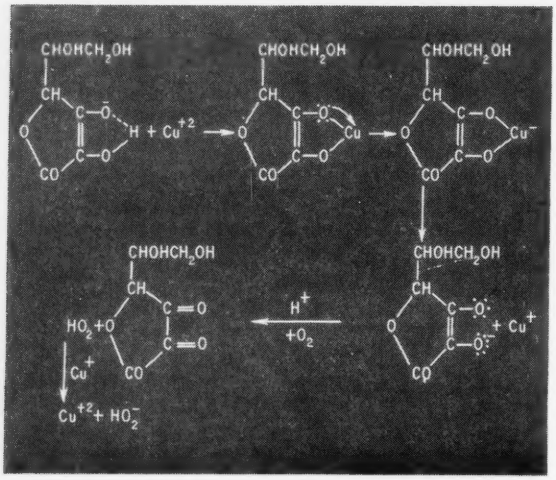
When a metal is capable of existing in more than one valence state, the combination of an organic ligand with the higher valance state of the metal may result in an electron transfer to the metal, and the initiation

*All complexes are 1:1, water molecules filling out the remainder of the coordination sphere; Ac=acetate, Cit=citrate, Sal=salicylate.

Simple acid-base catalyst—Fig. 12



Cu-catalyzed oxidation of ascorbic acid—Fig. 13



of a chemical reaction as a consequence of this electron transfer.

Fig. 13 shows the mechanism for Cu(II) catalyzed oxidation of ascorbic acid as an example of this type of reaction.

There are many other similar reactions that have been studied in recent years, such as oxidation of ascorbic acid by hydrogen peroxide, the Mn (III)-catalyzed oxidation of oxalic acid, and the metal ion-catalyzed decomposition of organic 1,2-diols.

It is well known that traces of metal ions catalyze polymerization (i.e., gum formation) in petroleum, oxidation of cellulose, and the deterioration by oxidation or decomposition of many types of natural products.

Summary of Complexing-Agent Influences

Although all chemical and physical properties of metal ions may be said to be influenced by complex formation, the following effects are those considered most important and pertinent:

- Decrease in activity (and concentration) of metal ion.
- Increase in oxidation potential (for complexes with primarily ionic binding).
- Increase in solubility (sequestering action) with hydrophyllic ligands.
- Decrease in solubility (and increase in organic extractibility) when combined with hydrophobic ligands.
- Decrease in tendency of metal ion to hydrolyze and polymerize.
- Decrease in catalytic activity of metal ion (effect greatest when metal ion fully coordinated by the ligand).
- Change in color of the metal ion (a complex function of the structure of the ligand and the nature of the metal ion).

Uses of Chelating Agents in Chemical Processes

Chelating agents capable of reducing or controlling the activities of metal ions in aqueous solution, called sequestering agents, have been extensively applied to many products and processes.

In certain instances, it is necessary to remove the metal entirely to prevent deterioration of a product, or formation of an unsightly precipitate, or certain physical changes that may result from reactions of metal impurities.

In other cases, it is necessary to reduce the concentration of free metal ion, and make it available in considerable quantities at a reduced level.

Use of a sequestering agent may be indicated in these cases if some alternative method (such as removal of metal by a phase separation) seems to be impractical.

A partial list of applications of chelating agents is given in Table VI. For further details, see Refs. 3, 6.

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Platforming (catalytic reforming) units, such as this can convert straight-run gasoline fractions into a high-octane product by means of dual-function catalysts.

CATALYSIS

Here is a progress report on both the fundamental and applied aspects of catalysis. The emphasis is on the petroleum industry, where improved catalytic techniques have yielded higher-quality gasolines and more-valuable byproducts.

VLADIMIR HAENSEL, *Universal Oil Products Co.*

In recent years, the field of catalysis has seen considerable progress on two fronts. First, new catalytic methods have been introduced to effect highly selective reactions on a commercial scale. Second, the development of a number of new tools for studying catalytic phenomena has greatly increased our basic understanding of catalysis.

The advance in catalytic methods has been achieved through highly efficient and selective catalysts that can do their work under considerably milder conditions, with fewer undesirable side reactions. Higher yields of the desired products can thus be obtained.

Because they are highly selective, these catalysts require that the materials charged to the reactors be of considerably higher purity. A number of feedstock purification methods have been developed for this purpose.

The petroleum industry serves as an excellent example of the ready acceptance of new catalytic methods; in fact, over the last 25 years it has come to rely upon catalysis as its most potent refining tool. Nearly all of the gasoline consumed by the public at the present time is manufactured through catalytic processes.

In many instances, the original crude oil components are transformed in three different catalytic steps before being blended into the finished gasoline. These auxiliary processes serve as an integral part of the total refining picture—they make it possible to attain the maximum yield of the highest quality product from a barrel of crude.

Turning to the second aspect, progress in the fundamental understanding of catalysis has been very rapid. Some very interesting work has been done to elucidate the nature of the catalyst surface when it is subjected to the environment of the catalytic reaction. Considerable progress has also been made in studying the mechanism of catalytic reactions, and in determining the structure of catalysts by adsorption methods.

This paper will examine both the applied and fundamental aspects of heterogeneous* catalysts in the light of recent developments.

* In heterogeneous catalysis, the catalyst is not in the same phase as the reactants—it is usually a solid, while the reactants are usually vapors or liquids.

Catalysis in the Petroleum Industry

As one reviews the progress of petroleum refining, it becomes quite apparent that catalysis appeared to be the only reasonable solution for attaining the goals of reduced byproducts and improved quality of gasoline. Let us trace very quickly the steps by which catalysis has taken over.

One of the first catalytic methods was introduced by Ipatieff, who was able to convert the olefinic components of the refinery gases into gasoline. The next step in the progress of catalysis involved the reaction of the isoparaffinic components with olefins, to produce a high-quality paraffinic material known as alkylate. These two processes made it possible to recover the byproducts of the cracking reaction in the form of a high-octane gasoline.

Next came catalytic cracking. This resulted in a more efficient conversion of the heavier components of the crude into gasoline of high quality. The step that followed involved the conversion of the straight-run gasoline fractions into a high-octane product by means of catalytic reforming. Thus, at the present time, the bulk of the gasoline sold in the U. S. is made primarily by catalytic cracking and catalytic reforming, with catalytic polymerization and alkylation following in order of importance.

The application of modern catalysis may be described by using catalytic reforming as an example. Here, a dual-function catalyst is used to perform specific parts of the over-all reaction.

Let us assume that as starting material we have a gasoline that boils in the range of 150-400 F. and contains 45% paraffins, 45% naphthenes and 10% aromatics. This over-all material has an octane number of approximately 35. The object is to convert it to as high an octane number as possible with minimum side-reactions.

Obviously, we do not wish to do anything to the aromatic portion of the gasoline, because the aromatics are already high-octane-number components. The paraffinic constituents have an average octane number of about 15, while the naphthenic components, which are divided approximately 50-50 in the form of 5- and 6-membered-ring naphthenes, have an octane number of about 60.

The reactions by which the paraffinic and the naphthenic components may be converted into high-octane materials have been well-established. It is known that 6-membered-ring naphthenes can be converted into aromatic hydrocarbons. Five-membered-ring naphthenes must first be isomerized into 6-membered-ring structures and subsequently converted into aromatics, while the paraffins may be either isomerized into high-octane materials, or subjected to a dehydrocyclization reaction to convert them into aromatic hydrocarbons.

All of these reactions have their limitations, not only from the standpoint of equilibrium but also from the ultimate effect upon octane number. For example, if the paraffiins are isomerized even at very low temperatures, the final octane number of the isomerized paraffin fraction would still be too low for its use as a high-octane-gasoline component. Furthermore, it is apparent that an operating condition favorable for one reaction will not necessarily be favorable for another. Thus, the major advances in catalytic reforming have involved not the finding of new reactions but the proper balancing of the catalyst composition and operating conditions to produce the desired extent of the reactions taking place.

Conversion of Naphthenes

Let us first consider the conversion of 6-membered-ring naphthenes. The dehydrogenation of cyclohexane derivatives has been studied widely and it has been well-established that such a reaction takes place readily at atmospheric pressure and in the presence of a dehydrogenation catalyst such as platinum. However, if this were the only reaction taking place in catalytic reforming, the over-all increase in octane number of the product would be exceedingly small. Thus, it becomes necessary to work on the other components of the gasoline as well.

We do know that when converting 5-membered-ring naphthenes or cyclopentane derivatives into aromatic hydrocarbons, at one point or another in the course of the reaction, we require the breakage of the ring and the formation of a 6-membered ring. This, in effect, is an isomerization reaction and should be catalyzed by an acid component. Thus, we have set the necessary requirement for effecting the reaction; that is, the presence of a dehydrogenation catalyst and an acid catalyst.

If such a catalyst is then used for the conversion of gasoline, we find that the activity very rapidly declines because of poisoning. This poisoning is due to the presence of sulfur compounds as well as carbonaceous deposits on the catalyst. If we desulfurize the feedstock, we are still unable to operate because of the deposit of carbonaceous material on the catalyst. To overcome this second poison, we introduce hydrogen into the reaction system under pressure. This immediately reduces our conversion to a very low level and, therefore, makes it imperative that we operate at higher temperatures. So our next step is to raise the operating temperature to a point where we get substantial conversion of the 5- and 6-membered-ring naphthenes.

When operating under conditions that convert the naphthenes, the paraffins present in the system also react along a number of directions. Some of them undergo isomerization, others hydrocrack to lower boiling paraffins, while still others are converted into aromatics. At this point, if we make further adjustments in catalyst composition as well as in operating conditions, we can maximize the yield and product quality. We have then reached a point where a stable operation can be carried out with a relatively high yield.

Let us examine in greater detail the individual reactions that take place. As indicated before, the reaction

of a 6-membered-ring naphthene is straightforward; what we visualize is a contact with a dehydrogenation site followed by the release of hydrogen and the formation of an aromatic hydrocarbon.

With 5-membered-ring naphthenes or cyclopentane derivatives, the picture is somewhat more complex. Our chemical intuition tells us that the first reaction involves a contact with a dehydrogenation site. This results in the formation of a cyclo-olefin, which then has to migrate to an acid site, where it can undergo the rearrangement to a 6-membered-ring cyclo-olefin. When the isomerization step is complete, the cyclo-olefin has to migrate further to another dehydrogenation site and be converted into the aromatic.

At this point, we begin to worry about the distance between the individual sites in the catalyst structure and the various equilibria that exist in the over-all system. Thermodynamic measurements have shown that the cyclopentane derivatives are more favored at higher temperatures. This means that in order to convert the 5-membered-ring naphthenes into aromatics in substantial yields, the C_5-ring species must be removed (i.e., dehydrogenated) very rapidly.

In recent years, much work has been done on the conversion mechanism of 5-membered-ring naphthenes into aromatics. One of the outstanding studies is that of Keulemans and Voge,[1] who investigated the behavior of a large number of 5-membered-ring naphthenes at 350 C. with a platinum-alumina-halogen catalyst. The experiments were made in the presence of hydrogen at slightly above atmospheric pressure.

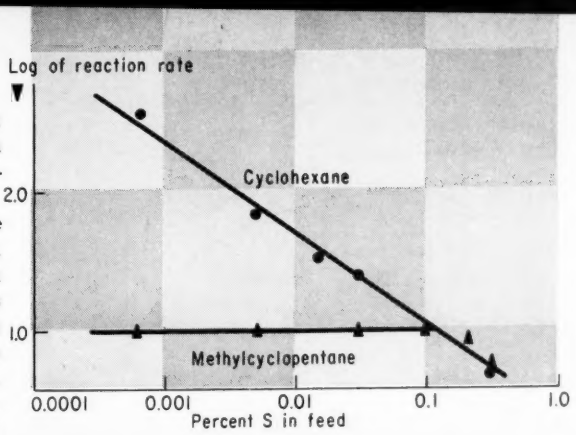
The authors postulated the following sequence of reactions during the conversion of a 5-membered-ring into an aromatic:

1. Dehydrogenation to olefin at a metal site.
2. Migration of an olefin to an acid site.
3. Addition of a proton at the acid site to form a carbonium ion.
4. Isomerization of the ion by carbon skeleton rearrangement.
5. Release and migration of a new olefin.
6. Dehydrogenation of the new olefin to an aromatic at a metal site.

The first three steps, which can be considered as the initiation reaction, have been postulated by Bloch and co-workers[2] to take place according to the following reaction:

This is a reaction occurring on an acid site. On the other hand, Ciapetta[3] showed that in the presence of a dual-function catalyst, alkenes undergo isomerization at lower catalyst temperatures than the corresponding alkanes. This finding would support the three-step reaction leading to the formation of the carbonium ion; however, the initial dehydrogenation would occur at a site different from the one required for the subsequent formation of the carbonium ion.

Keulemans and Voge reasoned that, of all the steps involved in the conversion of 5-membered-ring naphthenes into aromatics, it is the isomerization of the carbonium ion by carbon-skeleton rearrangement that limits the rate of reaction. The authors postulated that "the rate of the series of reactions leading to a particular product will be given by the relative amount of the carbonium ion multiplied by one factor for the rate of isomerization and another [factor] for the number of equivalent isomerization paths." The latter is usually referred to as the statistical factor.



Effect of sulfur on rate of reaction—Fig. 1

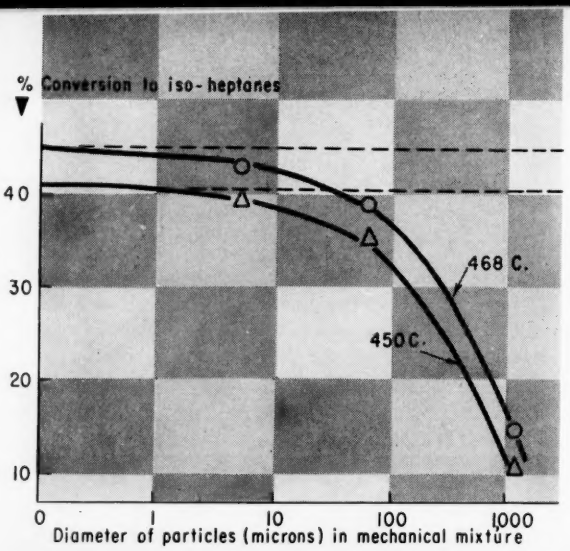
The authors then assumed the relative abundance of tertiary, secondary and the least-stable primary carbonium ions to be in the ratio of tertiary/primary, 32, and secondary/primary, 16. The number of equivalent isomerization paths was determined on the basis of the usual carbonium ion mechanism. Data on the conversion of some of the cyclopentanes were used to calculate aromatic hydrocarbon yields from all the cyclopentane derivatives studied. The results are shown in the following table:

Aromatic Contents of Products at 350F.

Compounds or Class	Number of Compounds	Aromatics, % Wt. Observed	Calculated
Methylcyclopentane	1	2.6	1.4
Ethylcyclopentane	1	25	22
Dimethylcyclopentanes	5	2.3	2.8
n-Propylcyclopentane	1	27	22
Methylethylcyclopentanes	5	21	23
Trimethylcyclopentanes	7	4.1	4.1
1, 1-Dimethylcyclohexane	1	34	44

It can be seen that the agreement between the observed and calculated amounts of aromatics produced is very good, indicating that the established theories on carbonium ion transformations are applicable in catalytic reforming reactions.

While this study postulated that the rate-limiting reaction is the carbon-skeleton rearrangement, there are ways of shifting the rate-limiting reaction from one type to another. For example, in our work we have studied the conversion of cyclohexane over the platinum-aluminum-halogen catalyst and have measured the rate of reaction in the presence of various amounts of sulfur. We have found that a linear relationship can be obtained between the logarithm of the sulfur



Effect of varying the catalyst's particle size. Fig. 2

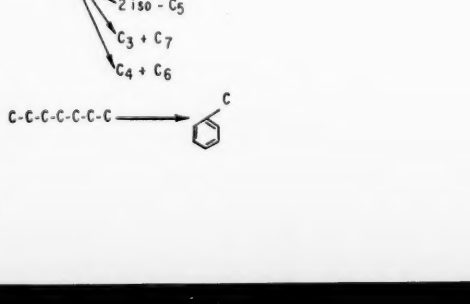
content and the logarithm of the rate of reaction.

When methylcyclopentane was processed under the same conditions and in the presence of various amounts of sulfur, we observed that the rate at which methylcyclopentane is converted to benzene is virtually constant until the sulfur concentration reaches such a high value that the conversion of the intermediate cyclohexane becomes rate limiting. From this point on, larger amounts of sulfur have the same rate effect as they do on the conversion of cyclohexane. This is shown in Fig. 1.[18] Here, the rate limiting reaction is not the carbon-skeleton rearrangement, but the rate of dehydrogenation of the cyclohexane to benzene.

Conversion of the Paraffins

We have now established that the naphthenic hydrocarbons are converted over a dual-function catalyst through a series of reactions, depending upon the original structure of the naphthene; and that the reactions take place over different sites on the catalyst structure. Let us now turn to the paraffins.

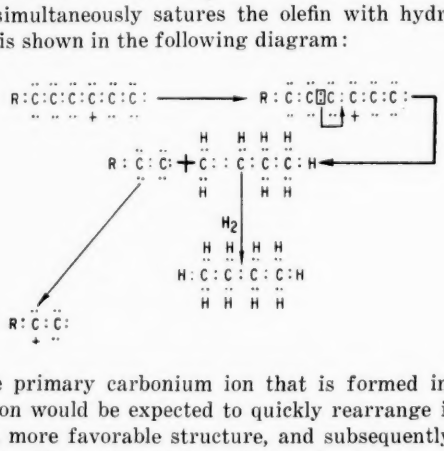
As indicated earlier, the paraffins can take three differential reaction paths in the presence of a dual-function catalyst. The over-all results are shown by the following equations involving isomerization, hydrocracking and dehydrocyclization:



Isomerization of paraffins can be visualized as taking place in the same way as isomerization that is postulated for a naphthenic hydrocarbon by Keulemans and Voge. The six-step mechanism involves two individual migrations, the first from a dehydrogenation site to an acid site, and then the reverse migration from an acid site to a dehydrogenation site. In considering these migrations, it is obvious that distances between the two types of sites must become an important criterion, as the point is reached where the distances are so great that reaction will no longer take place. Weisz and Swegler[4] have investigated the effect of a mechanical separation of the two types of sites, and compared the performance of the resulting catalyst with that of an impregnated catalyst used in the isomerization of normal heptane. Their procedure involved grinding the individual catalyst components into various sizes and then compressing the resulting powders into larger particles. The results are shown in Fig. 2.

It appears, from the data, that when distances above 100μ separate the two types of sites, the catalyst is no longer effective in promoting the reaction. Impregnated or co-precipitated catalysts will have much smaller distances between the different types of sites, so that the migration from one site to another will not be the rate-limiting part of the reaction. Under normal conditions of operation, using a dual function catalyst, an equilibrium product is obtained.

Hydrocracking is a somewhat more complicated reaction that is greatly influenced by hydrogen partial pressure. Our early concepts of hydrocracking involved the formation of a carbonium ion, followed by the movement of the electrons from the *beta* position to the carbonium ion carbon. This generates a new carbonium ion in a *beta* position as well as an olefin, and simultaneously satures the olefin with hydrogen. This is shown in the following diagram:



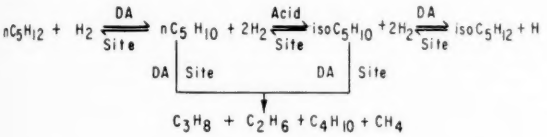
The primary carbonium ion that is formed in the reaction would be expected to quickly rearrange itself into a more favorable structure, and subsequently exchange with another hydrocarbon molecule to continue the chain of reaction.

More recently, Myers and Munns[5] have studied the hydrocracking of pentane, hexane and heptane in the presence of a large number of platinum-containing catalysts. They have found that the hydrocracking activity of such catalysts is better correlated with the dehydrogenation activity (DA) of the catalyst (as measured by cyclohexane dehydrogenation) than with

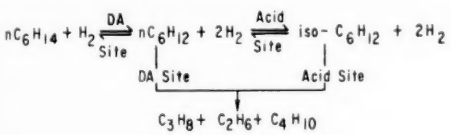
the isomerization activity (as measured by the isomerization of *p*-xylene).

These and a number of other observations have led Myers and Munns to postulate that the formation of lower paraffins first proceeds on a dehydrogenation site, to give an olefin. This is followed by either a skeletal isomerization to another olefin or by hydrogenative cracking on a dehydrogenation site.

The authors postulate that the isomerized olefins can also undergo hydrogenative cracking on the same dehydrogenative site. Thus, for pentane, the over-all picture is as follows:



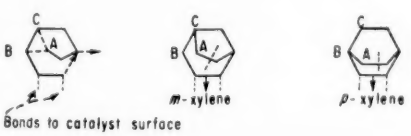
These authors point out that for higher hydrocarbons, acid-catalyzed cracking is also important, and would take place as follows:



Since in catalytic reforming we deal primarily with paraffins of considerably higher molecular weight, we would expect that the second mechanism—i.e., acid-catalyzed cracking—would predominate.

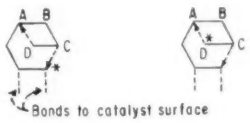
The dehydrocyclization reaction is of considerable importance in catalytic reforming, particularly where stocks are relatively lean in naphthenes, and where the aromatic production has to come almost entirely from the paraffinic components. Both the mechanism and the catalyst requirements of this reaction are very complex. The lower paraffins, such as hexane and heptane, undergo dehydrocyclization less readily than do the higher paraffins. In fact, we have found that the C_{10} and C_{11} paraffins are almost as readily converted into aromatics as are the corresponding naphthenes, at the usual catalytic reforming conditions.

Considerable work has been done on the mechanism of dehydrocyclization. Herington and Rideal[6] have suggested that, in the case of normal octane, two bicyclooctanes are formed as intermediates. The subsequent cleavage between the two bridge carbon atoms produces meta- and para-xylene. These structures are shown below:



Using the radioisotope-tracing technique, Mitchell[7] found that when *n*-heptane-1-C^{14} was the starting material, the methyl-label amounted to 27-29% and not to the 50% that would be indicated under previously proposed mechanisms for this reaction.

According to this investigator, the trans-annular bridge proposed by Herington and Rideal may be used to explain the results obtained.



Mitchell demonstrated that the breaking of the 4-membered ring, *ABCD*, at any one of the bonds in the two compounds will lead to 25% methyl-labeled toluene, assuming equal concentrations of the two compound species, and equal bond-rupture tendencies.

More recently, Pines and Chen[8] investigated the cyclization of *n*-octane-1-C^{14} and showed that the mechanism of Herington and Rideal may apply in some instances. However, the data indicate that the mechanism of dehydrocyclization apparently depends on two factors.

The first of these involves the chcaracteristics of the catalyst. For example, a chromia-alumina catalyst can be made to dehydrocyclize normal heptane by different mechanisms, by changing the intrinsic acidity of the alumina. The hydrolysis of alumina isopropoxide produces an alumina with a high intrinsic acidity, while an alumina with a low intrinsic acidity is obtained from potassium aluminate.

Pines, et al, pointed out that the duration of the experiment—in other words, the age of the catalyst—is an important contributor to the reaction path, and thus constitutes a second factor. The authors postulated that 5-, 6-, 7- and 8-membered rings may be intermediates in the dehydrocyclization of normal octane.

If composition and age of the catalyst can affect the mechanism of the reaction, the experimental conditions should also have a profound effect.

Most of the mechanism studies have been carried out at atmospheric pressure both in the presence and absence of hydrogen. Commercial catalytic reforming operations involve the recycle of substantial amounts of hydrogen under pressure. A platinum catalyst is employed in conjunction with an acidic support. The change in catalyst activity is relatively slow, particularly when compared with the very short experiments used in the mechanism studies.

The early work of Greensfelder, et al.[9] on the dehydrocyclization of heptane in the presence of a molybdena-alumina catalyst showed that this catalyst gave about 25% toluene both at atmospheric and at 20-atm. pressure. However, a chromia-alumina catalyst produced a high yield of toluene at atmospheric pressure, but none at all at the higher pressure.

It was also observed that the chromia-alumina catalyst was not capable of isomerizing normal paraffins, while the molybdena-alumina catalyst could effect this reaction.

One can conclude that were the mechanisms for dehydrocyclization the same for both catalysts, there should

not be such a profound effect of pressure. Apparently, pressure has an important effect on the catalyst itself, so that the type of sites present at atmospheric pressure are no longer available at elevated pressures. We thus have to accept the possibility of multiple mechanisms for the dehydrocyclization reaction.

The above discussion has covered the major reactions of naphthenic and paraffinic hydrocarbons in catalytic reforming. As pointed out earlier, the operating conditions and catalyst compositions are balanced, in order to produce an optimum yield of high octane gasoline. The basic design of catalytic reforming units includes multiple reactors to compensate for the endothermic heat of reaction, and a hydrogen recycle to minimize the carbon formation on the catalyst.

In recent years, still-higher octane requirements have made operations more severe; this has resulted in the use of somewhat lower space velocities, and in some cases, in *in situ* regeneration of catalyst. A large number of the units are now equipped with pretreatment facilities for the removal of impurities from the feed to the reformer.

New Tools in the Study of Catalysis

The catalytic chemist has always dreamed of being able to observe the behavior of the reacting molecule when it comes in contact with the catalyst. A number of tools have been devised to do exactly this. Unfortunately, certain limitations have arisen that make it difficult to study some of the more interesting reactions. However, a fundamental approach has been made, and the results obtained are of great significance.

A good example is the work of Eischens and his co-workers[10] on the infrared spectroscopy of chemisorbed organic molecules on various catalytic structures. There is no question that different spectra are observed when these molecules are adsorbed on the catalyst; however, in many instances, reference spectra are lacking, thus making it necessary to theorize extensively on the nature of the intermediate that exists at the time of reaction. When further developed, infrared spectroscopy should be of tremendous importance in tracing the course of the reaction.

Mapes and Eischens,[11] in some of their early work, pointed out that with the silica-alumina cracking catalyst, one could differentiate between Brönsted acids (proton donors) and Lewis acids (electron-pair acceptors) by observing whether ammonia molecules or ammonium ions are present when ammonia is adsorbed on the catalyst. These studies indicate that most of the ammonia is chemisorbed on Lewis rather than Brönsted sites.

In addition to infrared spectroscopy studies, investigators have tried to detect changes in some of the other properties of a catalyst during a chemical reaction. Much has been done by Selwood[12] on the magnetic properties of catalysts, particularly metals, both during the chemisorption of the reactants as well as during the reaction itself.

A comparison of two methods of observing catalytic reactions is of interest. Pliskin and Eischens[13] studied the ethylene-hydrogen-nickel system by the infrared method, while Selwood[14] investigated the same system using magnetic measurements.

Two mechanisms are possible. The first involves an associative adsorption of ethylene on the nickel, whereby a double bond is opened to form a single bond between each carbon atom on the surface. The second involves a dissociative mechanism, in which CH bonds are broken.

Both investigators show that an associative chemisorption of ethylene is produced when the latter is added to the nickel surface that has previously been pretreated with hydrogen. However, when no hydrogen is present, the infrared studies indicate a dissociative mechanism, while the magnetic measurements indicate the associative step.

A number of possibilities exist that could reconcile these differences. All in all, both tools are extremely useful in extending our understanding of what happens on the catalyst surface.

No discussion of recent advances in catalysis would be complete without mentioning the work by Gwathmey and co-workers[15] on the influence of crystal face in catalysis. Again, in the case of the reaction of hydrogen and ethylene over nickel, it was established that the (321)* crystal face was the most active for the hydrogenation reactio nwhile the (100) face was the least active.

The effect of pore size and pore-size distribution in catalytic reaction has been the subject of a number of investigations. Some of the more important contributions in this field have been made by Wheeler,[16] who studied both the rate-limiting effect of the pore size, as well as the effect of poisons on catalytic reactions. Wheeler pointed out that if the poison is located at pore openings the effect does not correspond to the fraction of the surface actually covered by the poison, but is much greater. Because of the trend towards greater use of dual function catalysts, where migrations between sites located within various pores of the catalyst must occur, such work becomes very important.

Basic Theory of Catalysis

The above has dealt primarily with performance of a catalytic material, giving explanations of how a catalyst participates in the reaction. The real "philosopher's stone" in catalysis is the explanation of *why* a catalyst is a catalyst. Although this question is as old as catalysis itself, recent years have witnessed a concentrated effort to provide an answer.

This is particularly true in the field of semiconductors as applied to catalysis. Semiconductors can be classed as being between metals and insulators, and their conductivity can be enhanced by increasing the

* These *Miller Indices* denote relative direction of crystal plane.

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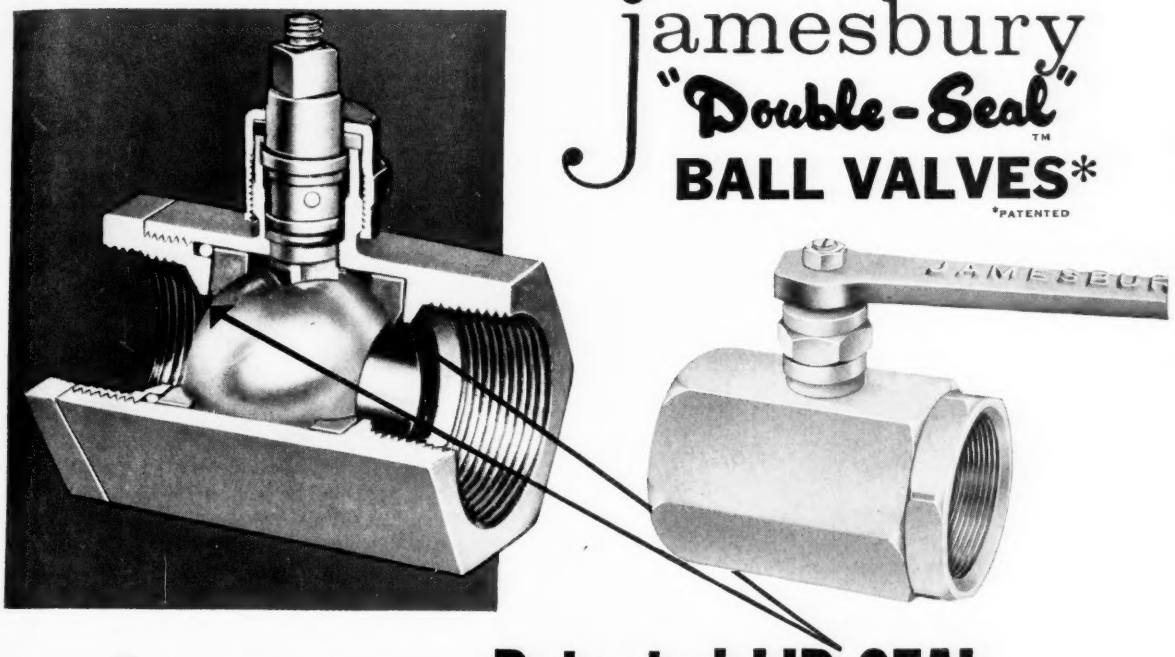

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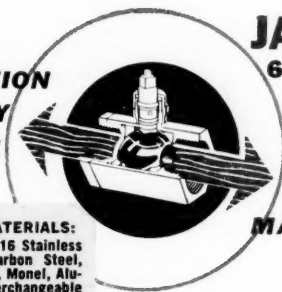

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temperature or by introducing impurities. These impurities can act as either electron acceptors or electron donors, and are normally referred to as catalyst "dopes." Catalytic behavior can be varied by doping, and thus a change in the electronic properties of the semiconductors can be related to catalysis.

One of the main contributors to the electron theory of catalysis is Wolkenstein.[17] According to this author, the steps involved in the theory are as follows:

First, chemisorption of a particle takes place on the catalyst. There are a number of different forms of chemisorption. Some "weak" or "strong" types of bonding will occur. In all cases, the different types arise through the contribution of either free electrons or free holes of the lattice. According to Wolkenstein, "... the possibility of different bonding types of chemisorption . . . is due to the ability of the chemisorbed particles to generate free electrons on free holes, and to give them up to the lattice."

Having established an electronic relationship between the chemisorbed particle and the lattice, the electron theory of catalysis next indicates that on the surface of a semiconductor, the free electrons and holes can be considered as free valencies. Such valencies can migrate through the crystal, and may move from the bulk to the surface—the bulk of the crystal acting as a reservoir supplying the free valencies. Strong chemisorption will occur through the contribution of the free valencies of the surface to the bond, while in weak chemisorption, the free valencies do not participate.

If one assumes that a free valence participates in the chemisorption, the chemisorbed particle can be considered an ion radical. Thus, some chemisorbed particles on the catalyst surface will have an increased reactivity due to the contribution of the free valencies, while other chemisorbed particles will have a lower reactivity.

The pre-existence of free valencies on the surface is not essential for the formation of the valence bond. Such valencies can be formed, however, at the time of chemisorption, similar to our concept of Lewis acids.

The next step in the electron theory is the transition from one form of chemisorption into another—involving merely a change in the character of the bonding with the surface. This, in effect, is an electron transition, and is treated in terms of the Fermi level.*

According to Wolkenstein, "Once an electron equilibrium is established, the relative amounts of the different forms of chemisorption on the surface and hence the reactivity of the chemisorbed particles, are uniquely determined by the position of the Fermi level." The position of the Fermi level on the surface of a semiconductor governs the rate of reaction.

The over-all result of the theory, according to Wolkenstein, is the following: "The crystal surface of a semiconductor, having a supply of electrons and holes that participate in the process as free valencies, acts as a sort of polyradical in heterogenous catalysis. It brings the free valencies into play, and this is its function as a catalyst in the process. In the long run, it affects the heterogeneous reaction rate in the same manner in which free radicals introduced into the gaseous phase affect the rate of a homogeneous reaction."

While the electron theory of catalysis has been applied primarily to semiconductors and not to metals, the surface oxide layers existing on such metals extend the applicability of the theory to much wider regions.

Serious attempts have been made to explain catalysis in terms of our modern theories, and to provide the necessary experimental proofs by using the best available tools. A single theory of catalytic action is unlikely to be developed. It is believed that we will finally arrive at a number of explanations, depending upon the type of catalytic surface, and the nature of the reaction to be catalyzed.

* In the quantum theory, the Fermi level represents the energy level than has a 0.5 probability of being occupied by an electron.

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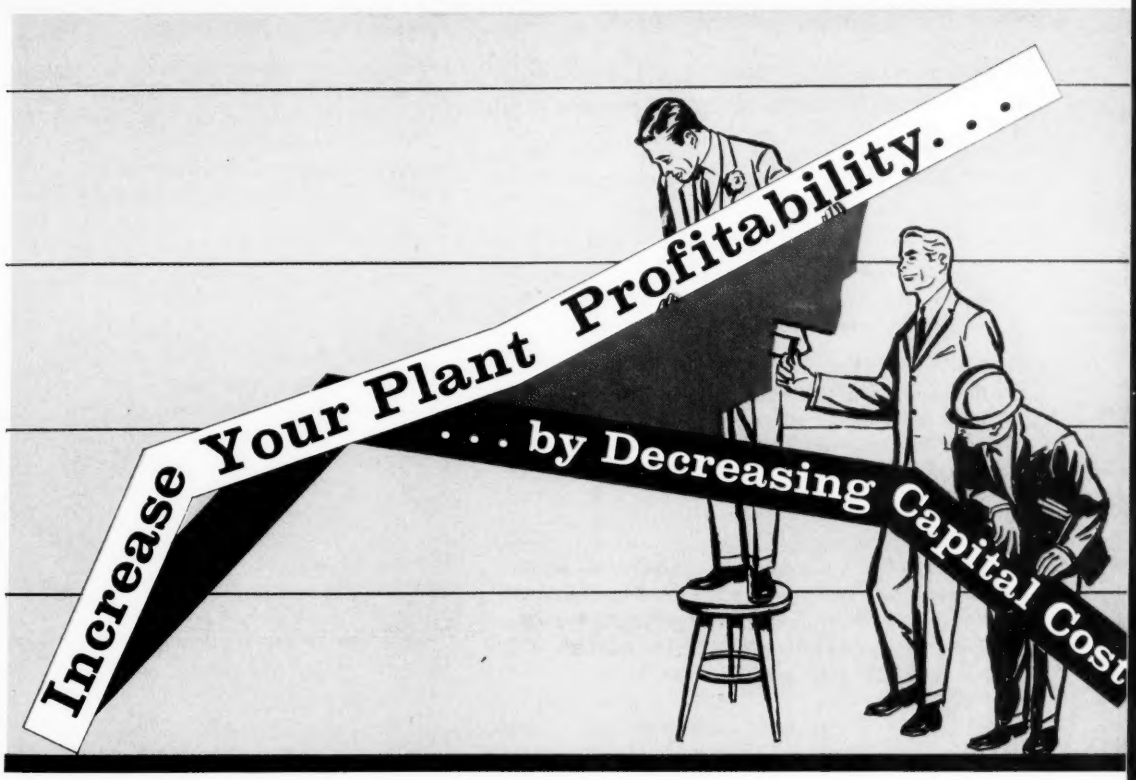
Meet the Author

VLADIMIR HAENSEL *received a Master's degree in chemical engineering from M.I.T. in 1937, and a Ph.D. in chemistry from Northwestern University in 1941.*

Dr. Haensel joined Universal Oil Products Co. in 1937 as a chemical engineer. In 1945, he was appointed coordinator of the Cracking Research Div., and ten years later became Director of Refining Research. Since January, 1960, he has been Director of Process Research.

Dr. Haensel has received Precision Scientific Co.'s Award for Achievement in Petroleum Chemistry (1952), an honorary D.Sc. degree from Northwestern University (1957) and the Professional Progress Award of AIChE (1957).



Reductions in direct fixed-capital costs are possible when management allows project engineers to design plants less conservatively by including risk as an element of design.

CHARLES E. CARROLL
The Dow Chemical Co.

Many organizations today expend a considerable amount of time and effort in an attempt to define and minimize risk in the various facets of their business. Much has been written on means of reducing risk in sales, raw materials, and even labor supply. There is one potentially very productive area in which very little appears to have been accomplished to date. I refer to the evaluation and actual use of risk in plant design.

Perhaps one of the primary reasons for this situation lies in the attitude of management of many otherwise forward-looking organizations. In considering the manufacture of a new product, these organizations seem quite efficient in evaluating the alternates in areas such as marketing and raw-material supply. When it comes, however, to establishing the costs of erecting the manufacturing plant, and commensurately the portion of the cost of production that is determined by the amortization and efficiency of the production unit, management accepts as unassailable a single answer from the engineering designer of the new plant or facility.

The relative error in this approach subsequently manifests itself either in the form of a decision not to build—only to find the competition can apparently build and operate a plant under like conditions and still make a profit; or a decision to build—and the discovery that profits are either nonexistent or marginal, caused by competition from a more-efficient plant.

Risk Elements in Plant Design

How, then, can this situation be rectified in an organization and how can the organization's competitive position be restored? Let us consider a few examples.

Insurance Risks—It is virtually axiomatic in plant design that nothing other than the best possible design is adequate when direct hazards to life and limb are involved. Beyond this point, many elements of design are directed by insurance company requirements. Since it is the obvious purpose of an insurance company to pay out the least possible amount of money in claims, it favors the "safest practice" in all elements of plant design that affect the risks covered by its policy.

The plant designer should realize that the interests of the owner and the insurance company are essentially adverse. The owner pays a premium to the insurance company as a hedge against loss. It is, therefore, unreasonable for him to also expend large additional sums to reduce the probability of loss in the design

Personnel of the hypothetical Mammoth Co. who affect design decisions of new plant

Mammoth's directors have given their approval to install a $5-million plant in the Southern Division to produce framus dioxide.

Project engineer

John Bough, a B.S.Ch.E., with eight years since graduation, receives a salary of $9,500 per year. He has been assigned the project design for the new $5-million plant.

Production manager

Michael Roe has held this position for five years since his transfer from the home office in New York. He has been with Mammoth since graduation as B.S.Ch.E. from Founder's University in 1938. His salary is $20,000 per year plus bonuses.

Plant manager

Sam Flow is to be in charge of plant operation and control of Mammoth's new plant. He will work with John Bough in its design. Sam holds a B.S.M.E. from Benefactor's Institute and has been 12 years with Mammoth.

of the plant, unless there is a commensurate decrease in the premium. In most cases, the most efficient plant design from the owner's viewpoint is the one in which expenditures for reduction of potential loss are reduced to the point just short of where the insurance premium would be increased. Admittedly this is a relatively difficult point to fix. However, to unilaterally include all design suggestions of the insurance carrier errs far in the other direction.

Process Risks—Many processes, especially new ones fresh out of the research laboratory, are not too well defined as plant-size equipment. Designers and operating people will inevitably lean towards conservatism in design of process units in direct proportion to the degree of lack of definition or experience with the operating conditions. This conservatism, unfortunately, almost inevitably increases the plant cost.

Many designers seem to forget that the principal purpose of building a plant is to enable a product to be manufactured and sold at a profit, rather than creating a structure that the designer can point to with pride. Theoretically, the most efficient plant that is possible to build is the one that would be completely worn out on the last day it was in productive use.

In actual practice, plants are normally maintained at something approaching their original condition throughout their useful life. Then an attempt is made to salvage as much as possible of the residual value upon abandonment. Hence, the designer's principal problem is to ensure the maximum return on invested and working capital over the useful life of the plant.

In almost every case, the problems faced by the designer can be solved by increasing the amount of fixed capital required to build the plant. A few of these are product quality, raw-material cost, labor costs, working capital requirements, maintenance costs and costs of unforeseen production interruptions. Thus, any increase in the invested capital in a given plant, if intellegently applied, reduces the risk of one or more of the above items that adversely affect the unit cost of the product. The real key to efficient plant design lies in the establishment and intelligent application of these risks.

How to Correct Inefficient Plant Design

What, then, is the solution to this problem of inefficient plant design? What are the symptoms of this corporate disease and what is its cure? The symptoms are quite common and easily recognizable. They are characterized by a decrease in net profit without a commensurate decrease in gross sales. If the organization, after examining the common reasons for this phenomenon, such as decreased labor efficiency, increased raw-material costs, increased selling expenses, reaches the conclusions that its plants are not as efficient as those of its competitors, it is time to apply the plant design treatment.

In order to set reasonable goals for this sort of plant, it is first necessary to establish and examine the magnitude of reduction of direct fixed capital that is required to solve the problems of the organization in question. An initial approach is to consider a few recent significant plant investments of different amounts. A good start is to re-examine the profitability of some recent plants that have been either considered or actually built, presuming a 10% reduction in the direct fixed capital.

If the organization does not have a satisfactory system for establishing these figures, a useful example is the one outlined by J. W. Hackney in "How to Appraise Capital Investments," (*Chem. Eng.*, May 15, 1961, pp. 145-164).

If a 10% reduction is not sufficient to be attractive, a reduction from 20 to 30% should be evaluated. After the percentages are established, one or two of these designs should be systematically re-evaluated by a group of competent design engineers to see if the required reduction could have been accomplished. A survey of this nature should be sufficiently detailed to indicate the kind of changes in the techniques by which the organization has been establishing its plant designs and the changes that will be necessary in order to achieve this greater efficiency in the use of capital.

It is manifestly impossible to draw general conclusions that would predict the results of such a program for any given company. However, recent experience indicates that an over-all 10% reduction is quite common when designs are subject to this kind of scrutiny, and 20% or even 30% is not at all unusual.

How to Evaluate Capital Reductions

In an attempt to provide a yardstick for evaluating the potentiality of this situation, let us examine a hypothetical organization and see where potential areas of improvement may lie.

• Type of industry. A process industry that might

be heavy chemicals, pharmaceuticals, petrochemicals, oil refining, food processing or a host of allied fields. Large parts of the discussion will apply to any industry with one or more active competitors on a price basis. Perhaps this includes everyone except government and certain public utilities.

• Size of company. Let us assume a large organization with central offices in New York and several manufacturing divisions scattered around the country.

• Name. Let us call it the Mammoth Co. (So far as I know, no organization exists now by this name or ever has existed.)

John Bough is a project engineer for Mammoth Co. He receives a salary of $9,500 per year. John has just been assigned as project engineer of a $5-million job to install a framus dioxide plant for the Southern Division. The plant is to be completed one year hence.

Let's take a look at John's job and its possible impact upon the net profit of Mammoth. If he really knows his business and turns in a real bang-up performance, the plant will cost $5 million. If, on the other hand, John does an average job, the plant will cost 10% more, or $5.5 million.

Another position in the Mammoth organization has the title of production manager of the Southern Division. Michael Roe has held this job for five years since his transfer from the home office in New York. He has been with Mammoth since his graduation as B.S.Ch.E. from Founder's University in 1938. He receives a salary of $20,000 per year plus bonuses that have averaged $7,000 per year for the last three years.

Let us examine Mr. Roe's job and its effect on the net profit of Mammoth. Mr. Roe has really done a fine job in the last three years. He has reduced direct labor costs, made more-efficient use of raw materials, and increased total production of the Southern Division 14% over the last three years. The total effect of this has been to increase the net profit before taxes of the division by $1 million per year. Of course, after taxes, this amounts to about $450,000. Naturally, Mr. Roe has a well organized and efficient staff to aid him in this effort.

Notice the interesting parallel between John Bough and Mr. Roe. For their years of work, both can make an approximately equal incremental contribution to the net profit after taxes of the Mammoth Co. A cursory examination of Mr. Roe's position, staff and past performance indicates the great probability that his contribution to the profit and welfare of Mammoth will continue for the coming year. He has a stable, well-organized labor force, raw materials are substantially purchased by competitive bids on long-term contracts, and his staff is alert to improving operations and anticipating difficulties.

What about John Bough? Will Mammoth spend 5 or 5½ million dollars on the framus plant? And, for that matter, how much control does John have over this expenditure in the first place?

Let's start out by asking the group leader who is John's boss. The group leader says: "While project engineers like John certainly are in a position to influence job costs, we have many other effective controls. We have an excellent engineering estimating section, and our estimates average within 10% of actual costs. Also, we have been able to hold our engineering expenditures to 9½% of total job costs last year."

Mr. Roe, the production manager, is even more positive on this matter of construction cost control. He says: "Sam Flow, our framus plant manager, and his staff will work directly with the engineering department to develop the most economical and efficient design for this plant."

Mr. Roe has spoken more truth than he realizes. What he has said, essentially, is that Sam and John will really determine the final cost of the plant. Let us see why this is so.

About the time the Framus process was being seriously considered by the research department, the engineering department was asked to make a rough estimate of the installed cost of a plant to produce 10 million lb./mo. The answer came out to $4 to $8 million. The profit evaluation looked reasonably good at this range, so work was carried through the pilot-plant stage. At the end of this period, plant cost was re-estimated at $6 million ± 25%. Sam and John were then turned loose on the problem. After spending $120,000 on preliminary engineering, the final estimate had a cost of $5,725,000, including a $600,000 contingency.

Design Procedures Reflect Experience

Up to this point, what controls have been applied to the efforts of Sam and John? At the outset, it was apparent to them that the plant had better not cost more than about $7 million—$6 million being much better, $5 million ideal, but $4 million would obviously create a lot of discussion about why the original estimate was so high.

Being reasonably experienced in this situation, Sam and John chart a course that is practical and realistic. As the design develops, Sam insists on features that will ensure the minimum difficulty in operating the plant, plus maximum efficiency in labor and raw materials. Sam well knows that Mr. Roe is really a bear on unplanned shutdowns. Also, the monthly operating report clearly brings out the direct labor ratio and any unusual maintenance expense. The route to success, so far as Sam is concerned, is quite clear. Build a plant that will have the minimum unplanned shutdowns, direct-labor and maintenance cost.

John's interests are generally identical with Sam's, except that he has the responsibility to see that the appropriation is not overspent. His principal problem is to be sure that the design is sufficiently well-defined to Sam at the time the money is appropriated, and to include all the features Sam has or will insist upon and still stay within the appropriation.

Both John and Sam have an additional potential personal benefit available by including as much overcapacity as possible in the design. Overcapacity takes care of errors in judgment in the original design and also looks very foresighted to management if subsequent increases in production rate are required.

All of these problems, John and Sam know, can be

solved if enough money is available. Then, as the job proceeds through final design and construction, Mr. Parkinson's phenomenon takes place: "Expenditures rise to meet appropriations."

Can Mammoth Build More-Efficient Plants?

Mammoth is thus faced with the problem of creating more-efficient plants. How should it go about this? Consider the combination of Sam Flow, the production man, and John Bough, the engineer. What is the real incentive for either of these men to reduce the capital outlay for the framus plant?

Successful capital-cost reduction in plant design involves, in most cases, a large degree of intelligent risk taking. Example: if Sam agrees to eliminate an installed spare pump, he takes the risk of a 4-hr. shutdown but saves $6,000 in plant cost. If there are 25 such pumps in the plant, the total saving is $150,000. If during the 10-yr. life of the plant, there are five unplanned shutdowns, each costing $10,000, Sam has acted in the best interests of the company. However, if these unplanned shutdowns all occur in the first six months of plant operation and as a result Sam is fired, his decisions were not in his best interest.

As for John, he may well save $200,000 in plant costs by specifying less-expensive materials of construction. However, if at the end of the first year's operation, the maintenance expense is $10,000 more than appears warranted, due to failure of one of these marginal vessels, and John is severely criticized as a result, you may rest assured that he will not repeat this error.

Let us now look at Sam's boss, Mr. Roe. Remember he is a real bear on unplanned shutdowns. Mr. Roe is no doubt correct in raising particular hob with all and sundry for unplanned shutdowns that are a result of error in operation or maintenance procedures. However, he might also create an atmosphere favoring expenditures by encouraging overly-safe designs.

Notice also the monthly operating report that is one of the important indications of the performance of Sam's department. The report is designed to encourage reductions in direct labor and maintenance costs. It does not, however, bring out the effects of increased capital expenditures on the profitability of the plant. Again, Sam is encouraged to spend more capital to save labor and maintenance.

Consider the factors of John's performance that the group leader considers important: (1) estimates are accurate within 10%, (2) over-all engineering costs have averaged 9½%.

The group leader appears to have missed the point. Estimating (ability to predict costs) does not in itself control or reduce costs. If John presents the estimator with a design that will cost $5.5 million, the estimator can do very little to reduce this. As for the 9½% engineering charge, this may well be an indication of poor management. An increased expenditure for engineering will certainly raise the percentage figure but may well decrease the total dollars spent for the job.

The above discussion has concerned itself with the reduction of capital costs for a given plant. The over-all goal of any investment is, of course, to produce the maximum net profit for the organization. In any instance of plant design, this goal can obviously be approached by reduction in labor, raw materials, or other significant items of cost. Since the basic approach to any of these is identical from a design standpoint, it will serve our purpose to state Mammoth's goal in simple terms: "Design and build a plant of equivalent capacity and efficiency for less money."

The solution to the problem for Mammoth appears to lie primarily in the performance of John and Sam. Let's develop this premise. Mammoth should:

- Designate an individual who will be responsible for the design and performance of the plant.
- Create conditions where this individual will want to build the plant for minimum cost.
- Provide him with sufficient information, assistance and authority to enable him to see that such a plant is designed and constructed.

Where should the project engineer come from? Should he be a member of the production department (Sam Flow), the engineering department (John Bough), or conceivably even a consultant's engineer?

Designer Might Be a Production Man

If the project engineer is a member of the production organization, his job will be not only to design but also to operate the plant in the most efficient manner. This system, while theoretically ideal, has many problems in practice. Some of these are:

1. Since designer will continue to operate the plant for a considerable period after construction is completed, additional plants will require the procurement and training of additional design engineers.
2. Project engineering requires a large amount of experience and skill to handle large projects. It is, therefore, very difficult to find people sufficiently qualified in both the project and production fields.
3. Training and subsequent responsibilities in production are probably not the best environment to produce a designer who will create minimum-cost plants. He won't take the necessary risks.

Consider the Engineering-Group Designer

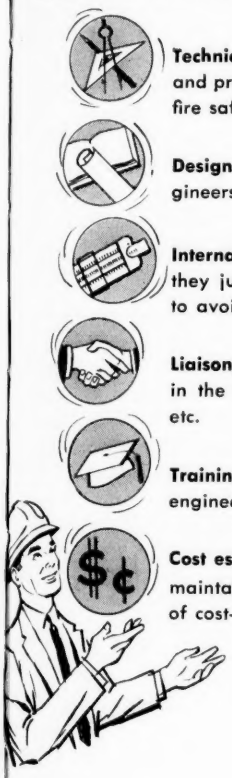
This is probably the most usual type of arrangement. It is logical to organize an engineering department to be responsible for design and construction of the plant. All too often, however, this responsibility is not accompanied by an equal degree of authority. For example, John's responsibility is to design the framus plant so that Sam can operate it successfully.

However, John does not have the authority to incorporate any features in this design without Sam's specific approval. The plant is thus being designed on a split-responsibility basis. Neither John nor Sam is in the position to make risk-taking decisions.

Designer Represents Engineering Consultant

There are many, apparently successful, instances

Central engineering department provides essential services to all project engineers



Technical experts, in fields such as equipment and process design, corrosion, waste disposal, fire safety and air pollution.

Design information, available to project engineers from a central index source.

Internal standards, for the company where they justify this function. Care to be taken to avoid over-standardization.

Liaison, among local engineering departments in the form of meetings, symposia, reports, etc.

Training and educational programs, in the engineering field on a company-wide basis.

Cost estimating system, to be developed and maintained along with the collection and use of cost-reference data.

of an owner saying to an engineer-contractor: "Build me a plant to make so much of product *X* and I will pay what it costs."

This is the true "turnkey" job. According to many who are in the engineering-construction business, it happens all too seldom.

Any discussion of the relative effect on total job costs of this method of doing business normally produces many and impassioned differences of opinion. Perhaps the strongest argument against this type of arrangement holds, in essence, that the interests of the owner and the consultant-contractor are adverse, insofar as the total job cost is concerned. To illustrate: if the project engineer is a consultant's man, it is reasonable to assume that he will protect the owner's financial interest in situations involving subcontractors and equipment vendors. It is not, however, reasonable to assume that he will act unilaterally in favor of the owner if in doing so he reduces the net profit to his employer.

Mammoth Decides on Project Engineer

Let us presume, following the above considerations, that Mammoth has selected John Bough to be the project engineer and has given him sufficient authority to create an economical design. This assignment of sufficient authority is probably the key decision in the solution to Mammoth's problem. Until now, John's actual goal has been to design a plant to satisfy Sam Flow. This goal is now changed to design a plant to make the maximum profit for Mammoth.

In the broader organizational sense, Mammoth is instructing its engineering department as follows: "You are now responsible for the complete design of the plant; and for its performance—producing to design specifications and costs."

It may well be argued that this is too big a job for John, that the position of project engineer has now grown to the point where it warrants someone approaching Mr. Roe's caliber. Here is a job of great financial responsibility. It should be staffed properly to discharge this responsibility.

But let's assume that John fills the bill. What should Mammoth do to make him want to reduce capital expenditures? Two facts about John's present job function immediately seem worrisome.

1. No one, including John, really knows whether he could save any money on the plant design.
2. John, in his opinion, has everything to lose and nothing to gain by taking risks in the design in order to save money.

Both of these problems can be solved at least in part by greater management participation in plant design. Under Mammoth's present system, both Mr. Roe and Mammoth's chief engineer usually only become aware of the details of plant design in case of difficulty during subsequent operation of the plant. It is very difficult for John to explain how he saved $100,000 by using cheaper tank materials two years ago, if last week a $10,000 leak has occurred in one.

Both production and engineering management should be sufficiently familiar with a design to understand and approve the risks and resultant capital savings. Subsequent equipment savings can thus be properly judged against the over-all benefits. This can be handled with a minimum of executive time by the judicious use of meetings and reports.

Production people would normally raise another objection to this arrangement. Mr. Roe would explain it something like this: "It is all very well to assume that a project engineer like John Bough will be responsible for the design and specification performance of this plant, but what good is he to us away up there in central engineering in New York City?

"The engineering problem is not solved by merely building the plant and covering the initial startup. The way you people work now, the project engineer is off on another job long before the plant is even built. If I am going to delegate this amount of authority to the project engineer, I want someone who will be around to make sure that the plant actually does perform to design specifications and continues to do so."

Certainly a successful project engineer needs a good basic and up-to-date knowledge of how to design and supervise the construction of plants. These abilities can be found in a good number of well-qualified consulting engineers. What makes the job unique, however, and thus requires a carefully trained Mammoth

employee is the specific knowledge he has of the company and its people. Thus, a person who has a continuing familiarity with local conditions and who enjoys the confidence of local personnel is in a much better position to design a successful plant.

It appears that Mammoth would be better advised to keep its project engineers in continuous and closer liaison with the plants they design. This will probably result in a decision to station more project engineers in decentralized locations. This should produce better qualified people, since a necessary part of every project engineer's training should include a period of responsibility for plant maintenance and rearrangement.

In the accompanying table are some functions that are best accomplished in a central engineering department. These have to do principally with areas in which bigness as such is an obvious advantage.

In summary, a projected solution involves recognition of the following facts (with revisions made in the organization to cope with them):

1. Expenditures for new plant construction are a continuing factor in the company's net profit.
2. Efficiency with which these funds are expended is primarily controlled by the degree in which the company can maintain and use a force of effective project engineers.
3. Creation and maintenance of this force takes time, effort and interest on the part of all levels of management. Considering the training these people require, it is mandatory that they be maintained as an effective part of the organization regardless of the relative level of the company's plant expenditures.

Comparison to Recent Data

Applicability of this case study and its solution can be partially examined by reference to recent data. A good example is contained in the article, "In '61 Bigger Budgets for Growth," (*Chem. Week*, Apr. 1, 1961, pp. 21-22). This article covers all manufacturers in the chemical industry with gross sales of $1 million per year or more. Some significant extracts are:

- Total construction expenditures in 1960 for the 40 companies listed were $1.2 billion.
- Expenditures for construction appeared to average about 12% of gross sales.
- Average increase in gross sales from 1959 for the 40 companies is about 5%. Average increase in construction expenditure from 1959 is about 75%, with eight of the group reaching 100% and two in the 200% range.
- Several of the organizations stated that capital expenditures would rise 50 to 100% in 1961 compared with 1960.

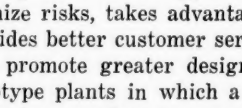
From these data, it appears that engineering departments of many of these organizations will be faced with two to four times more business in 1961, compared with 1959. Thus, an organization that is sufficiently equipped to handle an average volume of business as was experienced in 1959 currently might find itself vastly overburdened.

There is ample evidence to indicate that the efficiency for construction spending varies directly with the participation of company engineers on each job. Thus, it seems inevitable that an organization that expended $10 million for new plant construction in 1959 will get substantially less for its money if it spends $40 million for construction in 1961, unless it has made changes in its engineering department.

Looking to the future, today's competitive environment may well create some substantial changes in the way that engineering for new plant construction is carried on. Some of the more important ones are:

1. A realization that engineering under these conditions is a much more important and highly paid function than had been heretofore believed.
2. A realization of the great difference in incremental value of both people and organizations.
3. Efforts to examine and improve the methods by which plants are designed and built. This may well lead into the area of much more emphasis on selling consulting engineering on the basis of technical excellence rather than percentage markup. This will tend to foster engineering organizations staffed with recognized experts in certain fields, whose clients are willing to pay relatively large per diem charges.
4. A general examination of the relatively inept and unscientific liaison with the construction industry. This will probably lead to much more emphasis on plant design aimed toward control of construction labor requirements, and greater participation by owners to reduce contractors' risks in order to reduce bid costs.
5. A greater proportion of construction dollars spent on smaller local unitized plants. This type of construction tends to minimize risks, takes advantage of freight savings and provides better customer services. In addition, it tends to promote greater design efficiency by creating prototype plants in which a company's total output of a given product is spread out over a number of units. Hence, experience on the preceding unit can be successfully applied to improve design and operating efficiency.

Meet the Author



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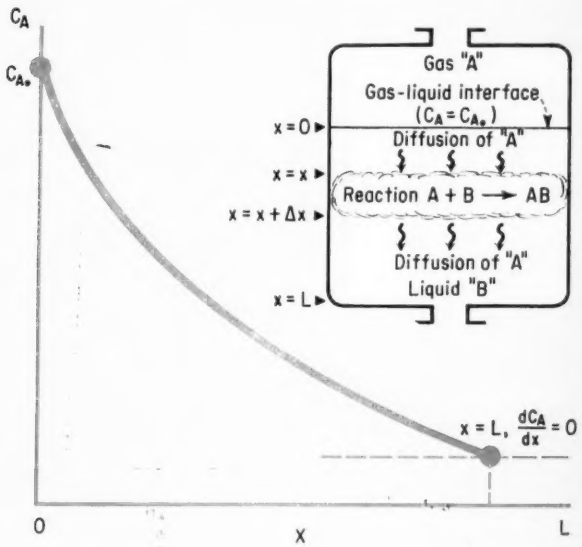
Deriving Transport Phenomena Applications



Here are analyses of transport phenomena involving diffusion, mass transfer, bulk flow, convection, and chemical reaction.

L. DOUGLAS SMOOT, *Brigham Young University*

In this final article on transport phenomena, we will apply the concepts developed in the earlier articles to the solution of complex engineering problems. (For earlier articles, see *Chem. Eng.*, Aug. 21, Sept. 18, Oct. 16.) Five examples of varying difficulty are shown below but space does not permit their complete mathematical solution. Further, the mathematical solution is not of major interest here.

The purpose of these examples is to illustrate the use of the general equations of conservation of mass, heat and momentum in describing problems mathematically. The examples present problems involving heat, mass and momentum transport. In one, equations for simultaneous momentum and heat transfer are developed.

The examples include equations in rectangular, cylindrical and spherical coordinates. Both steady- and unsteady-state situations are shown. Mechanisms of molecular and eddy diffusion, interphasial mass transfer, bulk flow, convection, and chemical reaction are treated. Thus, the problems help to illustrate the generality of the basic transport equations and enables their application to other problems involving these mechanisms.

With these concepts and limitations in mind, let us proceed to the problems and see how to develop the transport phenomena from the basic data given for each example.

To meet your author, see *Chem. Eng.*, Sept. 18, 1961, p. 186.

Example 1—Consider the steady-state absorption of pure gas molecules A into the liquid phase of pure B as shown in Fig. 1. On absorption into the stagnant liquid phase, A reacts with B to produce AB by a first-order irreversible chemical reaction:

$$A + B \xrightarrow{k} AB \qquad (1)$$

The absorption takes place in one direction only. The equation of conservation of mass written for component A in the liquid phase in rectangular coordinates (*Chem. Eng.*, Sept. 18, Table I) defines the process:

$$\frac{\partial C_A}{\partial t} = R_A - \left(v_x \frac{\partial C_A}{\partial x} + v_y \frac{\partial C_A}{\partial y} + v_z \frac{\partial C_A}{\partial z} \right) + D_A \left(\frac{\partial^2 C_A}{\partial x^2} + \frac{\partial^2 C_A}{\partial y^2} + \frac{\partial^2 C_A}{\partial z^2} \right) + \phi_A \qquad (2)$$

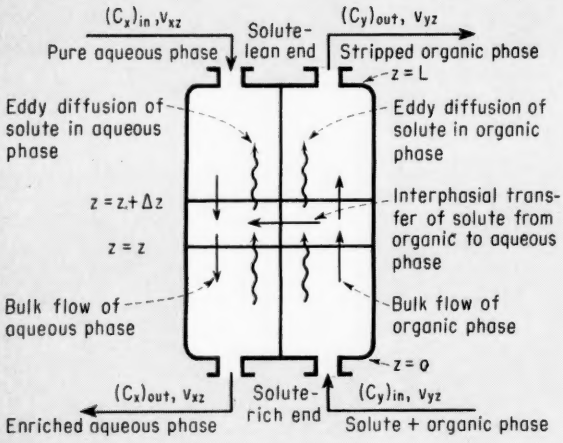
where:

C = Concentration of A in the liquid phase.
R_A = Rate of generation of A by chemical reaction.
v_x, v_y, v_z = Bulk-flow velocities of liquid in the x, y and z directions.
D_A = Binary molecular diffusion coefficient of A in B.
ϕ_A = Transport of A by means other than diffusion, reaction or bulk flow.

According to the conditions of the problem:

$\partial C_A/\partial t = 0$	Steady state.
$R_A = -kC_A$	First-order chemical reaction that is depleting A.
$v_x = 0, v_y = 0, v_z = 0$	No bulk flow of the liquid phase.
$\frac{\partial C_A}{\partial y} = 0, \frac{\partial C_A}{\partial z} = 0$	No concentration gradients in the y and z directions. Diffusion in $+x$ direction only.
$\phi_A = 0$	No means of mass transport other than reaction, flow or diffusion.

Liquid extraction—Fig. 2



Simplifying Eq. (2) by using the above restrictions, we find that the remaining terms are:

$$D_A \frac{d^2C_A}{dx^2} - kC_A = 0 \qquad (3)$$

Since D_A and k are assumed to be constant, Eq (3) is a second-order linear differential equation whose solution is:

$$C_A = A_1 \exp\left(x\sqrt{\frac{k}{D_A}}\right) + A_2 \exp\left(-x\sqrt{\frac{k}{D_A}}\right) \qquad (4)$$

Two boundary conditions are required to evaluate A_1 and A_2. Since steady state was assumed, then at $x = 0$, $C_A = C_{Ao}$. Further, diffusion is restricted beyond the bottom of the container. Hence, at $x = L$, $dC_A/dx = 0$. Substituting these two boundary conditions into Eq. (4) and solving the resulting simultaneous equations for A_1 and A_2, we obtain a final equation that predicts the concentration of A at any distance, x:

$$\frac{C_A}{C_{Ao}} = \frac{\exp\left[(L-x)\sqrt{\frac{k}{D_A}}\right] + \exp\left[-(L-x)\sqrt{\frac{k}{D_A}}\right]}{\exp\left(L\sqrt{\frac{k}{D_A}}\right) + \exp\left(-L\sqrt{\frac{k}{D_A}}\right)} \qquad (5)$$

The resulting concentration profile is shown in Fig. 1. The development of this equation by writing mass balance for differential element can be found in the literature.[1]

Liquid Extraction With Longitudinal Mixing

Example 2—In designing extraction columns, engineers assume plug flow of the two immiscible phases. However, in modern columns the means of agitation of the two liquid phases frequently gives rise to extensive mixing. For example, consider the extraction process shown in Fig. 2, where mass transfer is shown to occur by the mixing process (longitudinal eddy diffusion), by bulk flow, and by interphasial transfer. Assume that steady-state operation is established, and that no chemical reaction occurs in either phase.

The organic phase enters the bottom of the column, loaded with a solute. The heavier aqueous phase enters the top of the column and flows countercurrently through the rising organic phase, stripping the solute out of that phase. The enriched aqueous phase leaves the bottom of the column, and the purified organic phase leaves at the top.

Let C_x be the concentration of the solute in the aqueous phase, and C_y be the concentration in the organic phase. Then, the conservation of mass equation can be written in cylindrical coordinates (Table I, *Chem. Eng.*, Sept. 18, 1961) for both organic and aqueous phases as follows:

$$\frac{\partial C_x}{\partial t} = R_x + E_x\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial C_x}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 C_x}{\partial \theta^2} + \frac{\partial^2 C_x}{\partial z^2}\right] - \left(v_{rx}\frac{\partial C_x}{\partial r} + \frac{v_{\theta x}}{r}\frac{\partial C_x}{\partial \theta} + v_{zx}\frac{\partial C_x}{\partial z}\right) - \phi_x \qquad (6a)$$

$$\frac{\partial C_y}{dt} = R_y + E_y\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial C_y}{\partial r} + \frac{1}{r^2}\frac{\partial^2 C_y}{\partial \theta^2} + \frac{\partial^2 C_y}{\partial z^2}\right)\right] - \left(v_{ry}\frac{\partial C_y}{\partial r} + \frac{v_{\theta y}}{r}\frac{\partial C_y}{\partial \theta} + v_{zy}\frac{\partial C_y}{\partial z}\right) - \phi_y \qquad (6b)$$

R_x, R_y = Rates of chemical reaction in the organic and aqueous phases, respectively.
E_x, E_y = Eddy-diffusion coefficients in the aqueous and organic phases, respectively.
v_{rx}, $v_{\theta x}$, v_{zx} = Velocities of the aqueous phase in the r, θ and z directions.
v_{ry}, $v_{\theta y}$, v_{zy} = Corresponding values in the organic phase.
ϕ_x, ϕ_y = Rates of the interphasial mass transfer from the aqueous and organic phases, respectively.

According to the conditions of the problem:

$\partial C_x/\partial t = 0$, $\partial C_y/\partial t = 0$ Steady-state operation.
$R_x = 0$, $R_y = 0$ No chemical reaction.
$v_{rx} = 0$, $v_{\theta x} = 0$ Bulk flow of aqueous phase in z direction only.
$v_{ry} = 0$, $v_{\theta y} = 0$ Bulk flow of organic phase in z direction only.

If it is further assumed that the concentrations for the aqueous and organic phases in the radial r and angular θ directions are uniform at any value of z, then: $\partial C_x/\partial r = 0$, $\partial C_x/\partial \theta = 0$, $\partial C_y/\partial r = 0$ and $\partial C_y/\partial \theta = 0$.

In Eq. (6a), ϕ_x is the rate of interphasial mass transfer from the aqueous to the organic phase; and in Eq. (6b), ϕ_y is the rate of interphasial mass transfer from the organic to the aqueous phase. According to the two-film theory:

$$-\phi_x = \phi_y = K_x a(C_x^* - C_x) \qquad (7)$$

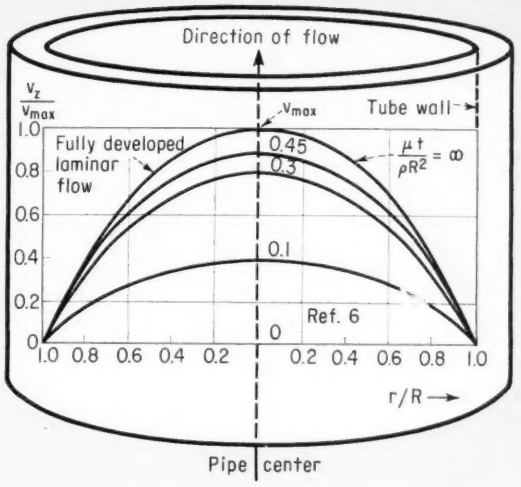
K_x = Over-all mass-transfer coefficient based on the aqueous phase, assumed to be constant.
a = Interfacial area for mass transfer per unit volume.
C_x^* = Concentration of solute in the aqueous phase that would be in equilibrium with the existing concentration of the solute in the organic phase.

For simple chemical systems:

$$C_x^* = mC_y \qquad (8)$$

where m is the equilibrium distribution coefficient.

Velocity distribution—Fig. 3



By simplifying Eqs. (6a) and (6b) according to the listed conditions of the problem, then cancelling those terms that are zero, and substituting Eqs. (7) and (8), we get:

$$E_x \frac{d^2C_x}{dz^2} + v_{zx}\frac{dC_x}{dz} + K_x a(mC_y - C_x) = 0 \qquad (9a)$$

$$E_y \frac{d^2C_y}{dz^2} - v_{zy}\frac{dC_y}{dz} - K_x a(mC_y - C_x) = 0 \qquad (9b)$$

Eqs. (9a) and (9b) are linear second-order differential equations with constant coefficients. By simultaneously solving these equations for C_x and C_y, an analytical expression for the concentrations C_x and C_y at any point z in the column is obtained. This solution is available in the literature.[5] The concentration profiles can then be used as a basis for extraction-column design where eddy diffusion occurs in the aqueous and organic phases.

Unsteady-State Laminar Flow

Example 3—Consider a Newtonian fluid of constant density and viscosity, initially at rest in a horizontal cylindrical duct[1] of length L and radius R. At time equal to zero, a constant pressure gradient $\Delta P/L$ is applied to the system, which initiates flow in the pipe. The object of the problem is to determine how the velocity profile changes with time in the r and z directions.

The equation of conservation of momentum in cylindrical coordinates can be applied to this problem. Since no flow exists in the θ and r directions, only the z component is considered. From Table III (*Chem. Eng.*, Sept. 18, 1961), the z component of the momentum balance is:

$$\rho\frac{\partial v_z}{\partial t} = \rho g_z - \frac{\partial p}{\partial z} - \rho\left(v_r\frac{\partial v_z}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta} + v_z\frac{\partial v_z}{\partial z}\right) + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2} + \frac{\partial^2 v_z}{\partial z^2}\right] \qquad (10)$$

From the conditions of the problem:

$g_z = 0$	Horizontal pipe.
$v_\theta = 0, v_r = 0$	Flow only in the z direction.
$\partial v_z/\partial t = 0$	No change of velocity in radial direction.
$\partial v_z/\partial z = 0$	Equation of continuity for an incompressible fluid where $v_\theta = 0$ and $v_r = 0$.
$\partial p/\partial z = \Delta P/L$	Pressure gradient constant for an incompressible fluid.

By making the indicated substitutions and cancellations, Eq. (10) becomes:

$$\rho\frac{\partial v_z}{\partial t} = \frac{\Delta P}{L} + \frac{\mu}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right) \qquad (11)$$

Initial and boundary conditions for the problem are:

Initial condition: at $t = 0$, $v_z = 0$ for $0 \leq r \leq R$.
Boundary condition 1: at $r = 0$, v_z is finite.
Boundary condition 2: at $r = R$, $v_z = 0$.

Eq. (11) is a partial differential equation, describing the fluid velocity as a function of time and position. Separation of these variables can be accomplished and an analytical solution obtained according to a procedure outlined by Bird, Stewart and Lightfoot.[1]

A graphical representation of the result is shown in Fig. 3. Notice that the centerline velocity is within 10% of the fully developed steady-state value when the dimensionless time parameter $\mu t/\rho R^2$ reaches 0.45. For water at room temperature flowing in a 2-in. pipe, fully developed flow would be approached after about 5 min. from application of a constant pressure difference.

Tangential Flow in an Annulus

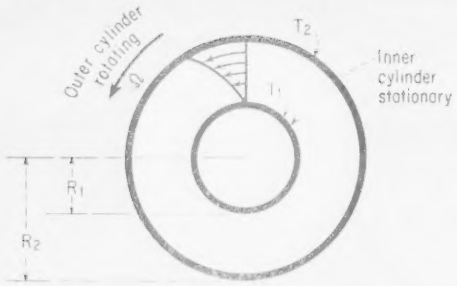
Example 4—An incompressible Newtonian fluid of constant density, viscosity and thermal conductivity is held between two coaxial cylinders of radii R_1 and R_2, respectively. The outer one is rotating at a steady angular velocity Ω. Assume that the wetted areas of the inner and outer surfaces are at temperatures of T_1 and T_2 as shown in Fig. 4. Steady-state operation is also assumed.

The object is to obtain an analytical expression for the velocity and temperature distributions in the annular space. First, the equation of conservation of momentum can be solved for the velocity profile. Then, this result can be substituted into the equation of conservation of energy, to obtain a differential equation describing the temperature distribution. This problem is of practical importance in determining heat effects in Couette-Hatschek viscometers.

From Table III (*Chem. Eng.*, Sept 18), we find the θ component of the conservation of momentum in cylindrical coordinates to be:

$$\rho\frac{\partial v_\theta}{\partial t} = \rho g_\theta - \frac{1}{r}\frac{\partial p}{\partial \theta} - \rho\left(v_r\frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{v_r v_\theta}{r} + v_z\frac{\partial v_\theta}{\partial z}\right) + \mu\left\{\frac{\partial}{\partial r}\left[\frac{1}{r}\frac{\partial}{\partial r}(rv_\theta)\right] + \frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2} + \frac{2}{r^2}\frac{\partial v_r}{\partial \theta} + \frac{\partial^2 v_\theta}{\partial z^2}\right\} \qquad (12)$$

Laminar flow—Fig. 4



Since $v_r = 0$ and $v_z = 0$, only the θ component is considered. Other conditions of the problem are:

$\partial v_\theta/\partial t = 0$ Steady state.
$g_\theta = 0$ No gravity in θ direction.
$\partial p/\partial \theta = 0$ No applied pressure gradient in θ direction.
$\partial v_\theta/\partial \theta = 0$ Steady flow of an incompressible fluid (from equation of continuity).

Consequently, Eq. (12) reduces to:

$$0 = \frac{d}{dr}\left[\frac{1}{r}\frac{d}{dr}(rv_\theta)\right] \tag{13}$$

Upon integrating Eq. (13) and evaluating constants of integration—having boundary conditions: at $r = R_1$, $v_\theta = 0$ and at $r = R_2$, $v_\theta = \Omega R$—the velocity distribution becomes:

$$v_\theta = \Omega R_2 \frac{(R_1^2 - r^2)}{rR_1}\Big/\frac{(R_1^2 - R_2^2)}{R_1 R_2} \tag{14}$$

From Table II (*Chem. Eng.*, Sept. 18), we find the conservation of energy equation in cylindrical coordinates to be:

$$\rho C_p \frac{\partial T}{\partial t} = \mu\phi_v - \rho C_p\left(v_r\frac{\partial T}{\partial r} + \frac{v_\theta}{r}\frac{\partial T}{\partial \theta} + v_z\frac{\partial T}{\partial z}\right) +$$

$$k\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 T}{\partial \theta^2} + \frac{\partial^2 T}{\partial z^2}\right] \tag{15}$$

where the viscous dissipation function[1] ϕ_v is:

$$\phi_v = 2\left\{\left(\frac{\partial v_r}{\partial r}\right)^2 + \left[\frac{1}{r}\left(\frac{\partial v_\theta}{\partial \theta} + v_r\right)\right]^2 + \left(\frac{\partial v_z}{\partial z}\right)^2\right\} +$$

$$\left(\frac{\partial v_\theta}{\partial z} + \frac{1}{r}\frac{\partial v_z}{\partial \theta}\right)^2 + \left(\frac{\partial v_z}{\partial r} + \frac{\partial v_r}{\partial z}\right)^2 + \left[\frac{1}{r}\frac{\partial v_r}{\partial \theta} + r\frac{\partial}{\partial r}\left(\frac{v_\theta}{r}\right)\right]^2$$

Eq. (15) can be simplified according to the conditions of the problem, previously enumerated, together with the additional conditions that $\partial T/\partial \theta = 0$ and $\partial T/\partial_z = 0$. The simplified equation is:

$$0 = \frac{k}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right) + \mu\left[r\frac{d}{dr}\left(\frac{v_\theta}{r}\right)^2\right] \tag{16}$$

By substituting the velocity v_θ as a function of the radius r [as given by Eq. (14)] into Eq. (16), the resulting differential equation describes the temperature as a functional of the radius:

$$\frac{k}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right) + \frac{4\Omega^2 R_1^4 R_2^4}{r^4(R_2^2 - R_1^2)^2} = 0 \tag{17}$$

Eq. (17) can be integrated twice, and the constants of integration evaluated for the boundary conditions: at $r = R_1$, $T = T_1$; and at $r = R_2$, $T = T_2$, to give the desired analytical expression for temperature T compared to radial distance r:

$$\frac{T - T_1}{T_2 - T_1} = \left[(N + 1) - \frac{NR_2^2}{r^2}\right] -$$

$$\left[(N + 1) - \frac{NR_2^2}{R_1^2}\right]\frac{\ln r/R_2}{\ln R_1/R_2} \tag{18}$$

where: $N = \dfrac{\mu\Omega^2 R_2^2}{k(T_2 - T_1)} \times \dfrac{R_1^4}{(R_2^2 - R_1^2)^2}$

When $N = 0$ ($\Omega = 0$), Eq. (18) describes the temperature distribution for stationary inner and outer shells, each at different temperatures.

Unsteady-State Temperature Distribution

Example 5—Consider a hemisphere of solid material of radius R heated uniformly over the flat base as shown in Fig. 5. Initially, the solid is at a temperature T_o. At time $t = 0$, a uniform temperature T_1 is applied to the base of the hemisphere. Loss of heat to the surrounding atmosphere occurs by convection over the curved surface. The heated base is perfectly insulated from the surrounding atmosphere.

We will determine the unsteady-state temperature distribution in the solid medium. Hence, $T = f(t,r,\theta)$.

From Table II (*Chem. Eng.*, Sept. 18, 1961), the equation of conservation of energy in spherical coordinates is:

$$\rho C_p \frac{\partial T}{\partial t} = \mu\phi_v - \rho C_p\left(v_r\frac{\partial T}{\partial r} + \frac{v_\theta}{r}\frac{\partial T}{\partial \theta} + \frac{v_\phi}{r\sin\theta}\frac{\partial T}{\partial \phi}\right) +$$

$$k\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial T}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 T}{\partial \phi^2}\right] \tag{19}$$

(Continued on p. 124)

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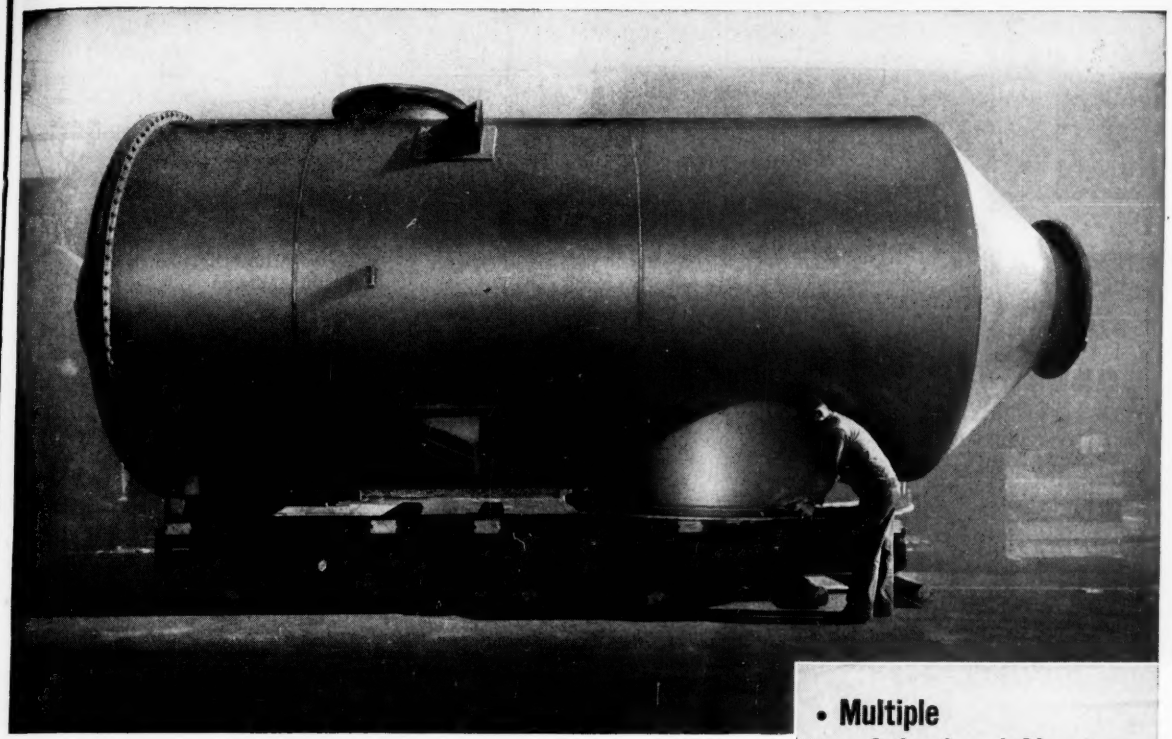

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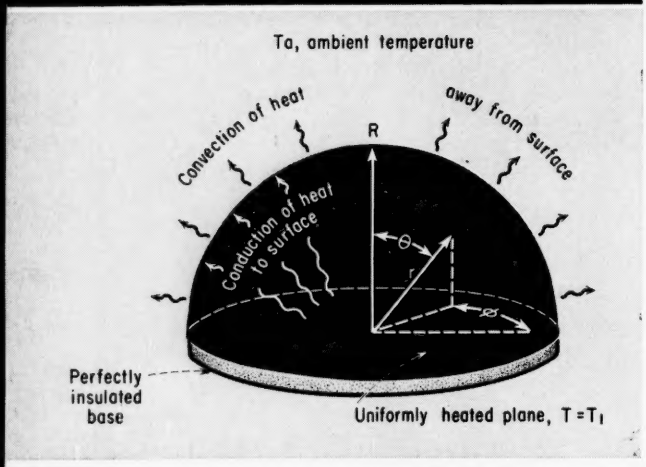
Unsteady-state conduction—Fig. 5



From the conditions given for the problem, we find:

$v_r = 0$ — No convection occurs in the solid medium.

$v_\theta = 0$, $v_\phi = 0$ — Convection from the surface of the solid to the atmosphere is taken into account in the boundary conditions.

$\partial T/\partial \phi = 0$ — Since the bottom plane is uniformly heated, the temperature at any set of values of r and θ is the same for all values of ϕ.

Performing the indicated simplifications, Eq. (19) becomes:

$$\frac{\partial T}{\partial t} = \frac{k}{\rho C_p}\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial t}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial T}{\partial \theta}\right)\right] \quad (20)$$

The viscous dissipation function ϕ_v is zero when the velocity terms v_θ, v_r, v_ϕ are zero. Bird, Stewart and Lightfoot[1] present formulas for ϕ_v in spherical coordinates.

The three independent variables (t, r, θ) of the partial differential equation can be separated by assuming a solution of the form:

$$T = F_1(t)F_2(r)F_3(\theta) \quad (21)$$

The resulting differential equations in t, r, and θ can be solved analytically with some effort, and the constants can be evaluated using the appropriate boundary conditions.

The preceding examples have been presented to indicate the wide variety of engineering problems in heat, mass and momentum transfer that can be solved with relative ease by using transport equations. Further, the examples serve to illustrate the setting up of complex problems using the equations and techniques discussed in earlier articles of this series.

In the future, as engineering problems become more and more complex, chemical engineers will see continued emphasis on fundamentals of engineering theory. Eventually, transport phenomena will be as common in engineering as thermodynamics is today.

For those interested in further developing an ability to define difficult problems analytically, several new books[2-4] are available on transport phenomena that contain a variety of illustrative problems.

Nomenclature

C_p	Heat capacity at constant pressure, Btu./(lb.)(°R.).
C	Concentration of solute, lb.-mole/cu.ft.
C^*	Equilibrium concentration of solute, lb.-mole/cu.ft.
D_A	Molecular diffusivity of A, sq.ft./hr.
E	Eddy diffusivity, sq.ft./hr.
g	Acceleration of gravity, ft./sec.^{2}
h	Heat-transfer coefficient, Btu./(hr.)(sq.ft.)(°R.).
k	Thermal conductivity, Btu./(hr.)(sq.ft.)(°R./ft.).
k	Chemical reaction-rate constant, hr.$^{-1}$
$K_x a$	Over-all mass-transfer coefficient multiplied by interphasial area, lb.-mole/(hr.)(sq.ft.)(lb.-mole/cu.ft.).
L	Pipe length, ft.
m	Distribution coefficient.
p	Pressure, lb./sq.ft.
r	Radial distance, ft.
R_i	Rate of generation of i by chemical reaction, lb.-mole/(hr.)(cu.ft.).
R	Radius.
t	Time, sec. or hr.
T	Temperature, °R.
v	Velocity component, ft./hr.
x, y, z	Distance in x, y, z direction, respectively.
Δ	Incremental change.
θ	Angular distance, radian.
μ	Viscosity, lb./(hr.)(ft.).
ρ	Density, lb./cu.ft.
ϕ	Angular distance, radian.
ϕ_A	Rate of mass transfer between immiscible phases, lb.-mole/(hr.)(cu.ft.).
ϕ_v	Viscous dissipation function.
Ω	Angular velocity, radian/hr.

Subscripts

0	Initial condition.
1	Point 1.
2	Point 2.
A	Chemical species A.
x	Aqueous phase or rectangular coordinate.
y	Organic phase or rectangular coordinate.
z	Rectangular coordinate.
θ	Cylindrical or spherical coordinate.
ϕ	Spherical coordinate.

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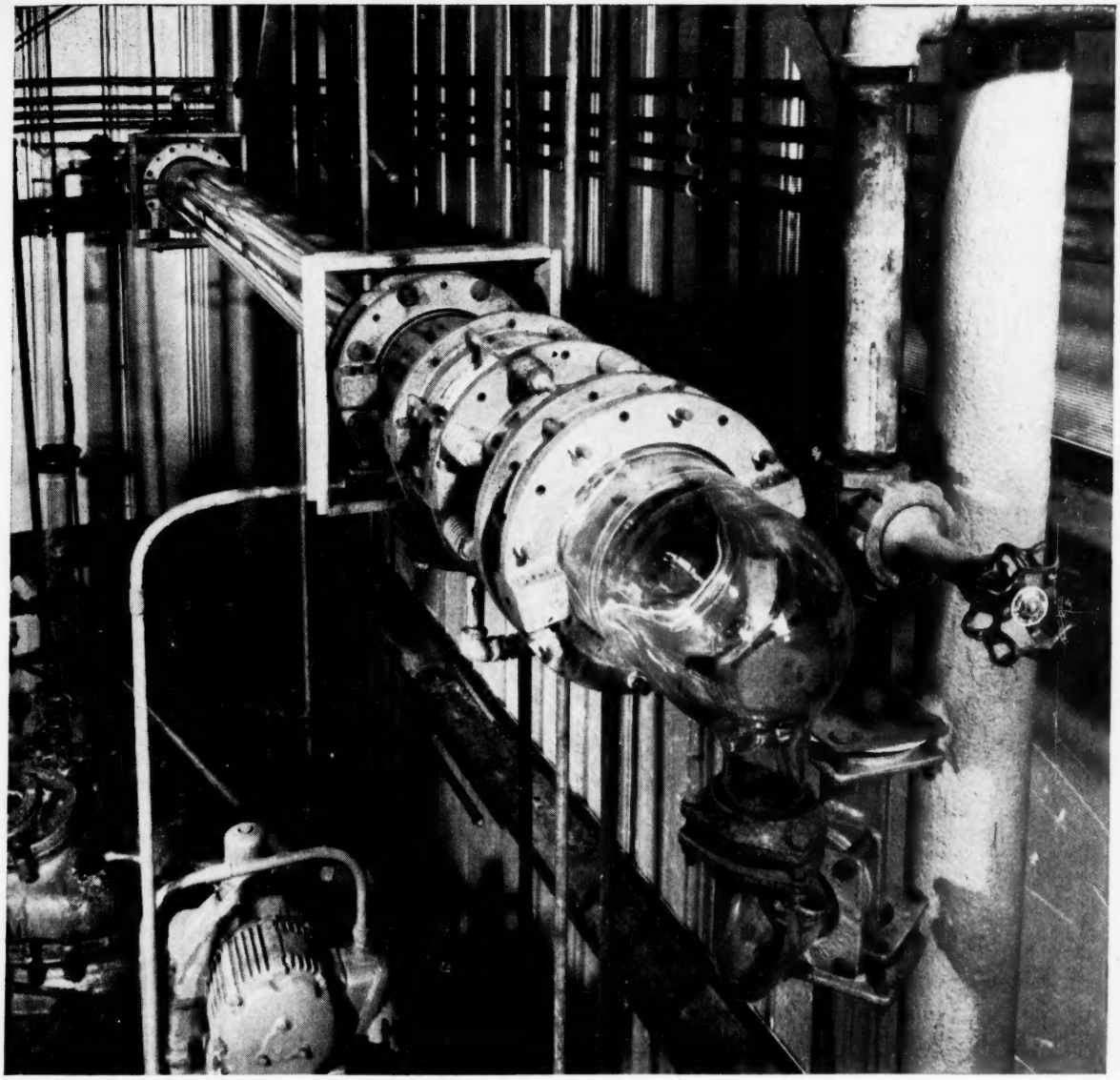
New CE Refresher . . .

The next CE Refresher article will appear in our Jan. 22, 1962 issue. This article will mark the return of our previous authors, Dr. Jesse Coates and Dr. Bernard S. Pressburg of Louisiana State University. Included in their review will be articles on adsorption, leaching and extraction, and on chemical reaction-rate concepts.



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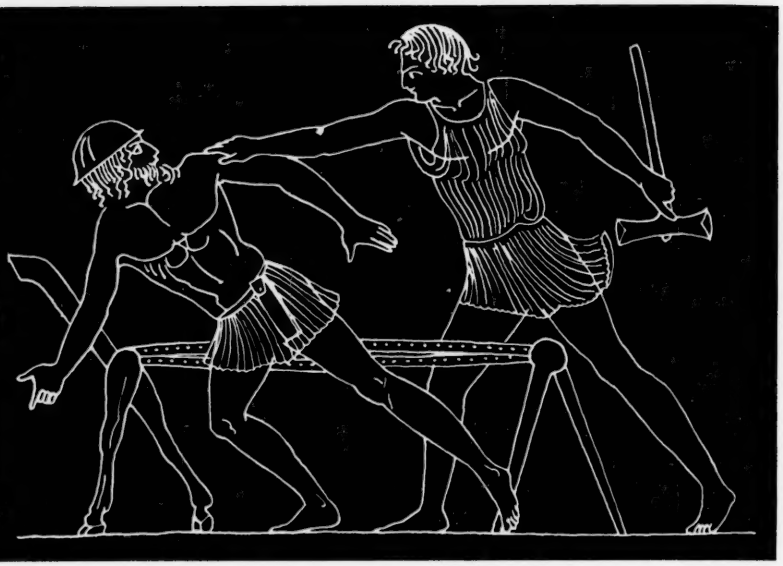
Four fuzzy perceptions cloud understanding of an engineer's career duties, prestige, status. Like the four legs of Procrustes' bed, they tend to force practice into a common, warped mold. Before you are stretched or shortened for the prescribed Procrustean pallet, read a psychologist's view of...



Some Myths of Professional Practice

S. M. BERND, *James N. Farr Associates, Inc.*

Procrustes earned a reputation among Attican travelers of being a difficult host. Welcoming the road-weary to his lodge, he would promptly rack them, or cut them to size, trying to fit them exactly to his bed. In many ways, our thinking about engineering and its role in society follows the Procrustean cue. This is particularly crippling when it's necessary to make the career choice of "engineering vs. management."

The psychological or motivational issues that are involved in transitional career choices are important to several parties:

- The production manager who is concerned about the morale of his engineering staff.
- The research manager who tries to understand the feelings and attitudes that may influence the creativity of his department.
- The educators and researchers of the academic world who are concerned about problems of occupational choice that face their students.
- The individual engineer who, confronted with an immediate need for decision, seeks more factual information about the management pathway.

The engineer is driven toward management by feelings of low status about his job and his position in the business community. At some significant point in his career, he feels the weight of a complex set of motivations and attitudes that deny him a sense of satisfaction and accomplishment in what he is doing. Both his job and his profession may bring an increasing sense of frustration and some career bitterness.

As a member of the engineering profession, he experiences envy and resentment toward the "higher" professions of medicine and law because of their greater status. As an individual employee, he compares himself unfavorably to men of comparable age and education who are managers in the company. He envies their higher earning capacity, both for the tangible standard of living it brings and its status symbolism. And he believes that their freedom of action and power within the organization, their contacts with top managements, denote greater recognition.

That Other Grass Is Always Greener

The engineer's attitudes of dissatisfaction and envy are clearly evident in a recent study of the Opinion Research Corp.* Warranting close study, the report offers the following striking statistics:

- Only 26% of the sample felt that professional status was recognized to a "very high degree."
- Between 14% and 26%, depending upon the individual question, felt that engineers were thought of as a "second-class profession," a "subprofessional group," "not respected as professionals in the community," and "no prestige—treated like mechanics."
- In individual responses, engineers felt they were

* "Engineering Professionalism in Industry," Opinion Research Corp., Princeton, 1960. A review of the major findings will be found in *Chem. Eng.*, July 25, 1960, p. 127.

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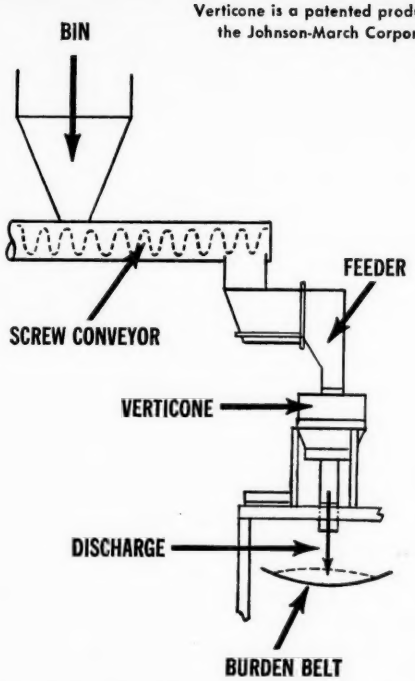

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treated like "peons" or "laborers" by some companies.

Clearly, the engineering profession is concerned about a feeling of low status and recognition. We could cite many other sources that parallel the conclusions of the Opinion Research Corp. study. Yet, we have to ask how much of this furor over professionalism is realistic, and how much is fuzzy-minded thinking.

To the engineer the management path seems to offer greater opportunity to accomplish life goals and attain greater financial rewards and security for his family. For some, this choice is successful and satisfactory. A managerial career yields new sources of satisfaction and a sense of personal development and fulfillment. Many top managers in the process industries started in the ranks as engineers or scientists. You probably know successful middle-line managers in nontechnical business functions who started that way, too.

Many other engineers, unfortunately, have a less happy experience in choosing management. As administrative or sales executives, they find the middle-management path even more frustrating than the routine of an engineer's job. These engineers have to face still another difficult job function and a subsequent functional adjustment.

To understand the successes and the failures, we have to go back to the motivational complex that led to the decision to change careers. Part of this complex has a realistic basis, part is unrealistic. It has some roots in the engineer's contemporary situation and some in the expectations that have been built up during his education.

Called or Calloused?

Much of the mystique of professionalism is based upon a cultural myth that is widely shared. This is the viewpoint that a profession is a "calling" that attracts individuals who follow altruistic motives of devotion to society and the community, and who serve the interests of others regardless of personal motives.

Opposed to these devoted persons are businessmen who supposedly follow their own self-interest and are motivated by profit, regardless of others. If professionals are altruists, and business men are egotists, then, of course, there are connotations of increased merit or personal worth in being a professional.

Certainly the professions occupy a unique, important place in the fabric of our society. They are necessary at almost every point in its functioning. Too, the activity of professionals as organized social groups follows different rules from that of organized business activity that is devoted to a profit motive. According to certain ethical criteria, this organized activity of the professional may have greater social value than that of the businessman.

But there is no reason to think that the motives of the individual professional are any different from those of one who follows a business career. The notion that a profession is a "calling" is based on an entirely false theory of human motivation that is embedded in traditional utilitarian economic theory. Talcott Parsons, a Harvard sociologist, points out that the differences between professional and business men exist at the institutional level, not at the personal level: "Doctors are not altruistic, and the famous 'acquisitiveness' of a business economy is not the product of 'enlightened self-interest'."

The engineer who has been led to share the feeling that he is personally meritorious and devoted to society because of his profession may face a rude awakening when he doesn't rate that status in the business community. He is likely to find himself a very small cog on a very large wheel.

College Cloister and Industry Hearth

An analogous set of unrealistic expectations regarding applied science activity is inculcated in the universities. There, the engineer's training usually includes a set of attitudes that are based on the scholar's ideal. Devoted to simon-pure pursuit of knowledge and truth for its own sake, university faculties often teach their students that such pursuit brings with it special worth and status.

Again, these attitudes are based on a fallacious theory of human motives. The organized activity of science and applied research may be disinterested and ethically neutral. (In these days of modern warfare, many would even dispute this.) But, the scientist is no different from the rest of us in his motivations. Indeed, the faculty of the typical college campus may be more competitive and aggressive than the average business enterprise, although the student is not likely to recognize it.

A Business Bond Doesn't Tie

The ORC study substantiates one further unrealistic attitude about status—the inevitable comparisons with law and medicine. Of the engineers sampled, 12-14% felt they would like to be "treated like doctors or lawyers" in terms of respect, dignity and prestige. Some engineers want to become more like lawyers and physicians, and have an association "something like the American Medical Association."

Physicians do have a unique position of high status and prestige. Traditionally, medicine, law and theology have been considered higher professions or "callings." Though this view is outdated and unrealistic, it is part of our mores. The medical profession —with a well-organized and active association—is well integrated into local community life.

But the unique prestige of the physician doesn't derive from a high degree of professionalism. It rises from emotional elements in the physician-patient relationship. The physician is a benevolent power figure who gives help to people in distress. The intense, personal bond between the individual in pain and the practitioner who employs curing and healing arts in the basis for the physician's prestige. To a lesser degree, the lawyer also solves individual and personal problems.

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The engineer does not. Even the consulting engineer who has client relationships keeps his activities at a business level. He can't possibly have the emotional impact for his clients that the doctor does. Though it is human to envy a successful man, it is unrealistic to become bitter about it.

Some Realistic Dissatisfactions

So far, we have talked about unrealistic expectations that lie behind the engineer's dissatisfaction. These give impetus to a drive toward a management career; but there are also strong realistic motives that play a powerful role.

Feelings of second-class citizenship on the part of the engineer can arise from several sources:

- He may be hemmed in by routine, uninteresting work assignments that he does not choose.
- He may find little opportunity for promotion because his problem solutions are part of a general effort.
- He may be treated as just another subordinate employee in a large company.

He compares himself with middle-line executives in his firm, sees that they enjoy greater status as well as higher salaries. The typical manager has greater freedom over his working environment and more power to make decisions. He directs others—assigns people, controls budgets, issues pay raises and influences promotions. The manager is also more likely to have a private office, a secretary and greater access to company information and planning. He has more opportunity for promotion, too.

In short, the engineer can well envy the manager's power, even though he may overestimate the freedom of action that the manager possesses, may not see how closely the manager is controlled by demands that are made upon him.

Equally important, the engineer can see that the middle-line manager is closer to the real source of power in the company—the top executives who have high status in the business environment and high prestige in the community. Having more contact with the manager than with the engineer, these business leaders will call on the manager for staff advice, for solution to line problems, for participation in long-range planning. And the glory and prestige of doing so rubs off.

An additional element of envy may enter his comparison when middle-line managers within the company are about the same age and have comparable background as the engineer. The engineer, too, sees some managers who are not as intelligent, but who have progressed further in terms of salary and responsibility.

Finally, in the typical organization there are probably some individual managers who are contemptuous of engineers with their narrow viewpoints. Others may openly regard engineers as servants of the sales force, which—they hold—is the real life blood of the business. The cumulative effect of these attitudes, coupled with those others mentioned above, is a strong motivational vector toward management and away from engineering.

Make the Step with Careful Measure

The engineer who is given an opportunity to step into a managerial position may misjudge his own adaptability to that function. Because he is a good objective problem-solver, he is likely to overestimate the importance of his ability, and to underestimate the difficulty of putting managerial plans into action. When a good deal of his emotional energy is invested in achieving constructive solutions to problems, he may not have the patience to undertake the subtle negotiations with higher-ups in the company that are necessary, or counteract the frustration of working through a human inertial system.

Some measure of basic assertiveness is necessary for success in most managerial positions. The engineer may overlook this quality and find the human problems very difficult. Freedom of action in handling budgets, promotions and other decision areas may be quite illusory under the weight of restrictions from above.

For the engineer, then, the transition to a managerial role can be difficult. He may find less excitement and power than he expected, and miss the stimulation and satisfaction of intellectual problems. As a manager, his time may be spent in routine, boring supervisory tasks where there is little tangible achievement over a long period of time. Then, too, he may be the center of petty bickering and position-jockeying from all sides. The problems of routine management—getting people to do things—may prove exasperating and frustrating.

The engineer who has newly transferred to a managerial post may encounter another source of dissatisfaction. Demands and criticisms of his superior may be a continual source of irritation. He may be called upon to take corrective action in a dozen minor problem areas a day, and then end up feeling that he has to sell himself to his bosses all over again.

This transition can be a successful one for the engineer or scientist who is able to get a sense of challenge and satisfaction from working with people, and who enjoys the area of negotiation and concrete action. But it will prove difficult for those who sense accomplishment only in abstract problem solving and whose principle motivating force for change is the desire for more status and recognition.

Meet the Author

S. M. BERND, *a consulting psychologist and vice president of his New York City firm, has observed many CPI engineers and scientists in their work. Educated at Columbia University and New York University, he holds a master's degree in social psychology from the former, a Ph.D. in clinical psychology from the latter. Bernd is a lecturer at City University of N. Y.'s graduate business school in applications of clinical psychology methods in industry.*

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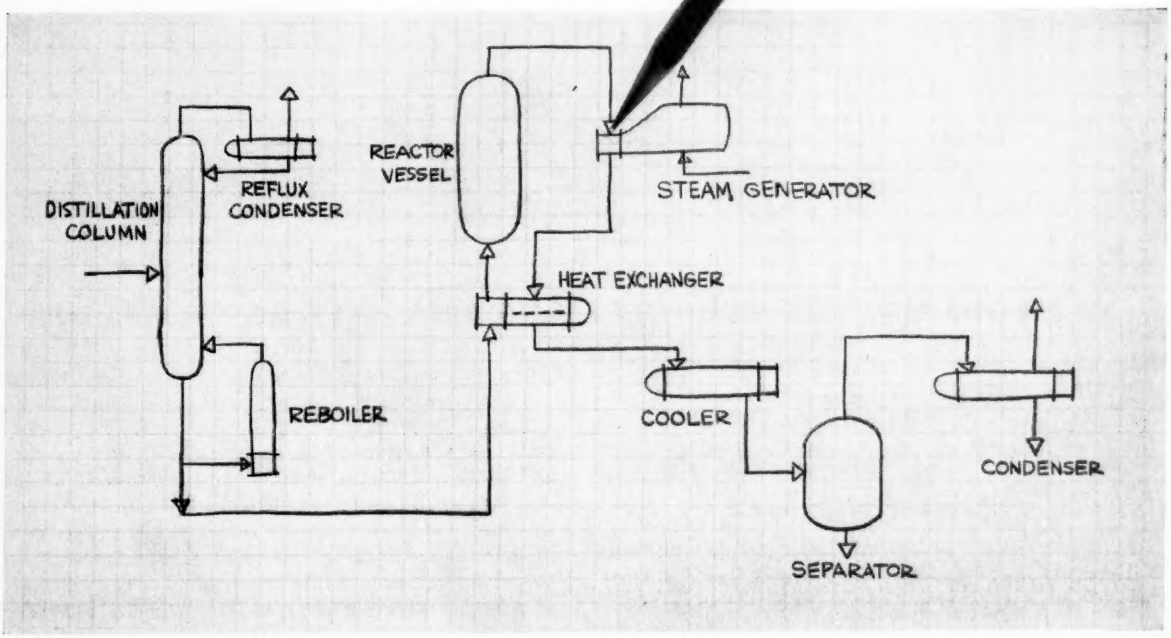

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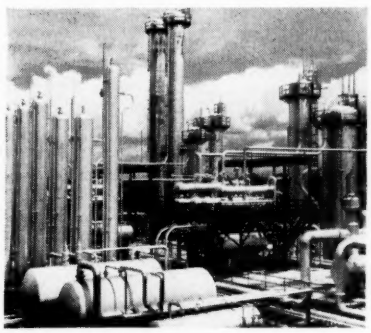

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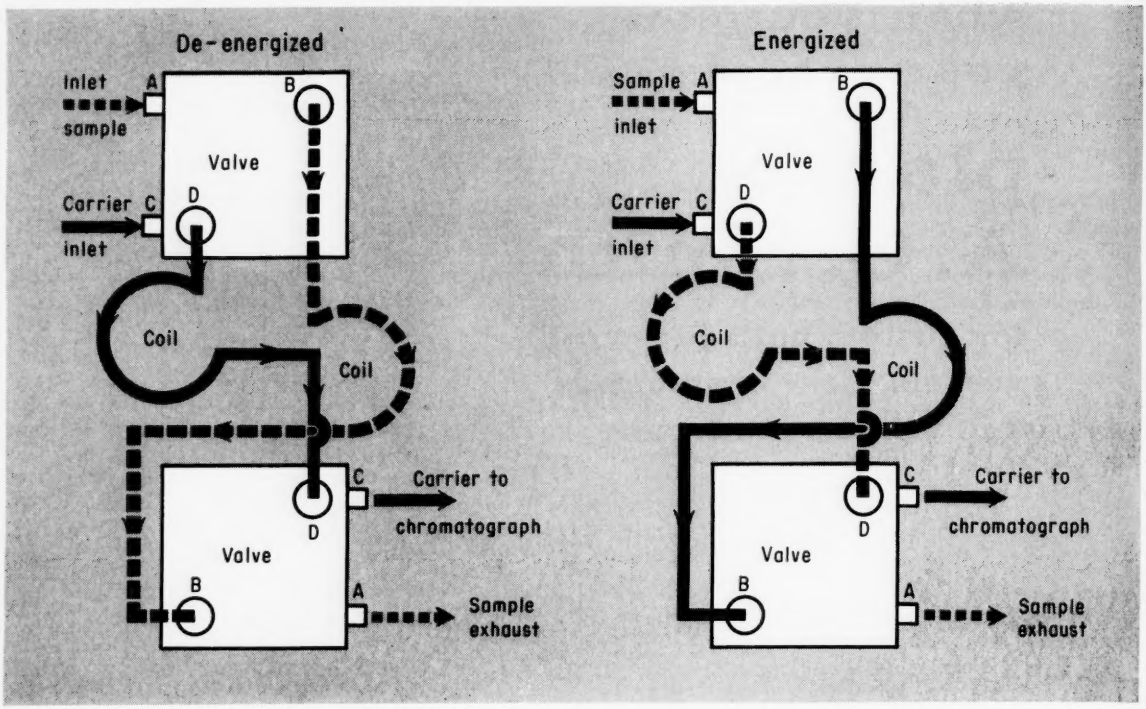

SOLENOID VALVES SIMPLIFY AUTOMATIC GAS SAMPLING

Winner of the September Contest*
GEORGE F. SHEA
Esso Research and Engineering Co., Linden, N. J.

A timer, which energizes and de-energizes two four-way solenoids, allows gas samples to be taken at any desired interval. The gas is trapped in a stainless steel coil, and then sent on for analysis.

This simple, inexpensive, automatic gas sampler can be used to take periodic samples for analysis by gas chromatograph or other analytical instrument. It can serve in a pilot plant, for absorption studies, for injecting pulses of gaseous feeds into apparatus, or for taking aliquot samples of tail gas over a period of time.

The device consists of two four-way solenoid valves (Skinner type V-935-DB2-150 normally closed–normally open, no neutral position) connected to an electric timer so that the circuits can be energized at 15-min. intervals, or any multiple of 15-min. intervals. The timer we used was an Intermatic Time Switch, Model T-965, which is run by an electric motor. By proper adjustment of this timer, samples can be taken at 15-min. intervals, ½-hr. intervals, ¾-hr. intervals, etc., up to once every 24 hr.

The two solenoids are connected by two stainless steel coils of ¼-in. O.D. by 3-ft.-long tubing. As the valves operate, the gas being sampled passes alternately through one or the other of these coils, while

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John Holmes, October Contest Winner

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$100 Annual Prize—At the end of each year, the period winners will be rejudged by the editors and the year's best awarded an additional $100 prize.

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Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant Notebook Editor, *Chemical Engineering*, 330 W. 42 St., New York 36.

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the carrier gas from the gas chromatograph passes through the other.

In this way, a quantity of process gas is trapped in the coil every time the valves operate, and is picked up by the carrier gas and injected into the chromatograph. By varying the length or diameter of the sample coils, the sample size can be changed at will.

The sketch shows how the automatic sampler operates. When the valves are de-energized, the gas sample stream enters the upper valve at port *A* and leaves it at *B*. Then it flows through the right-hand coil, enters the lower valve at port *B* and leaves at *A* to exhaust. The carrier gas enters the upper valve at *C*, leaves at *D*, flows through the left-hand coil, enters the lower valve at *D* and leaves through *C*.

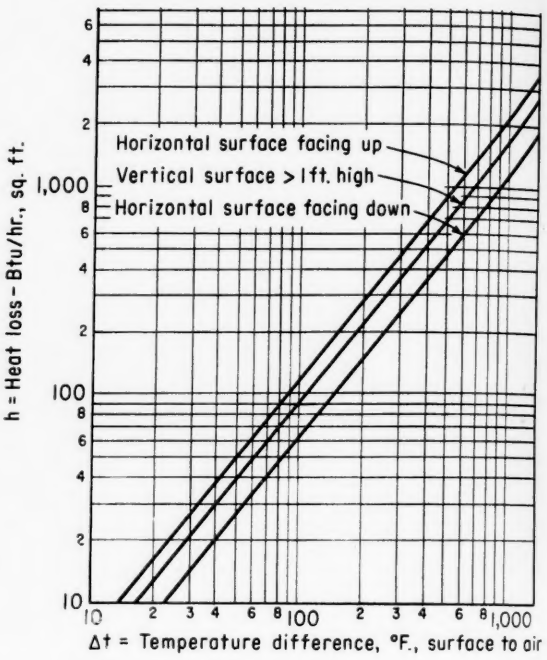
When the valves are energized, however, the gas sample stream enters the upper valve at *A* leaves at *D*, flows through the coil on the left, enters the lower valve at *D*, and leaves through *A* to exhaust. The carrier enters the upper valve at *C*, and leaves it at *B*, flowing through the coil on the right and pushing the trapped gas sample into the lower valve at Port *B* and out of it at *C* into the chromatograph.

The particular solenoids used in this apparatus are operable at temperatures up to 180 F. and pressures up to 150 psig. By using high-temperature coils in the valves, however, and special sealing materials, it should be possible to build a sampler for up to 450 F.

We have found, from chromatograph traces, that the sampler will inject essentially identical volumes of gas each time the same coil is energized. If the two coils are made with the same internal volume, the size will be identical for all samples. By using different size coils, however, it is possible to take alternate large and small samples, if desired.

The parts used in this sampler cost about $65, and it can be assembled in a short time. It permits continuous, unattended monitoring of any gaseous stream that is compatible with the materials of construction of the solenoid valves.

CONVECTION HEAT LOSSES FROM FLAT SURFACES


Horizontal surface facing up
Vertical surface > 1 ft. high
Horizontal surface facing down
h = Heat loss - Btu/hr., sq. ft.
Δt = Temperature difference, °F., surface to air
10
100
1,000

EDWARD J. GIBBONS
Colgate-Palmolive Co., Jersey City, N. J.

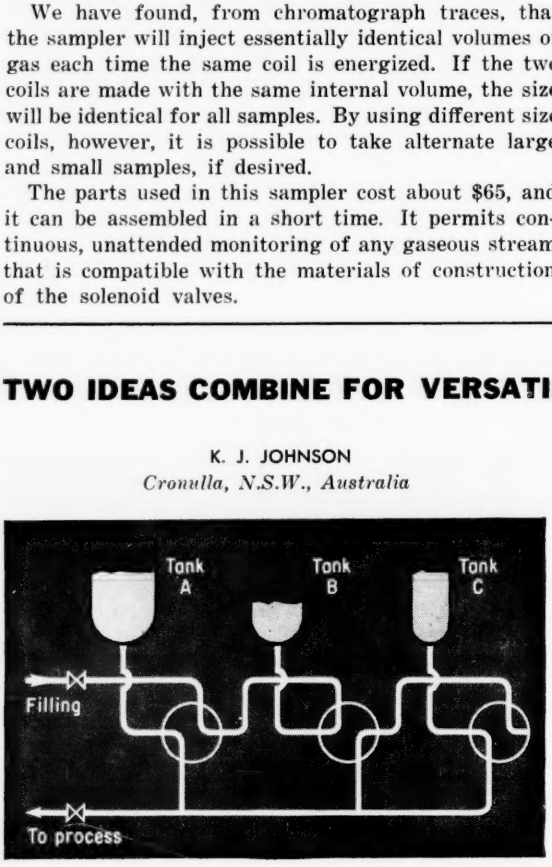
This chart gives convection heat losses from flat surfaces by natural convection. It solves the equation

$$h = c\,(\Delta t)^{0.25}\,\Delta t \text{ Btu./hr./sq. ft.}$$

where $c = 0.38$ for a horizontal surface that faces up, 0.30 for a vertical surface greater than 1 ft. high, and 0.20 for a horizontal surface facing down.

TWO IDEAS COMBINE FOR VERSATILE TANK INSTALLATION

K. J. JOHNSON
Cronulla, N.S.W., Australia

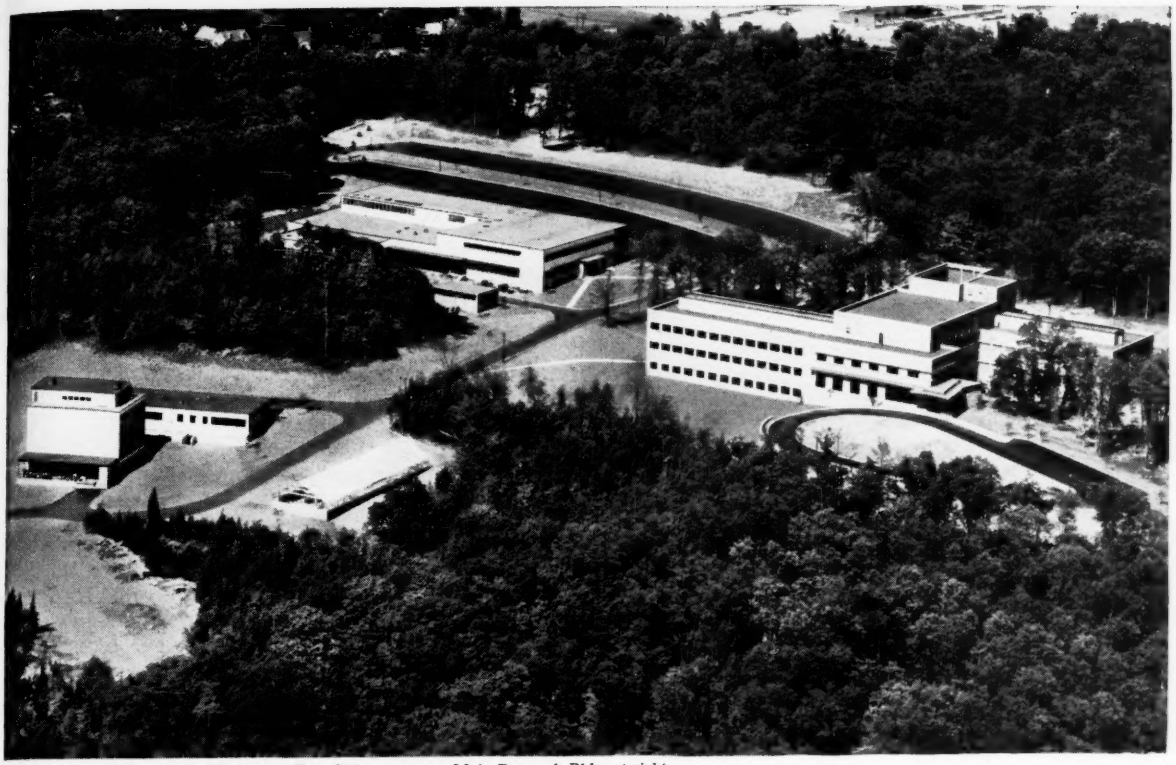


This idea is based on two previous Plant Notebook items (*Chem. Eng.*, Jan. 25, 1960, p. 122 and Oct. 3, 1960, p. 117). The first of these showed how the principle of "Hydraulic Paradox" could be used to divide a batch of liquid into desired proportions in tanks of differing diameters.

The second article described the use of four-way valves for foolproof filling or emptying of several tanks connected to the same supply line.

The sketch shows how these two ideas can be combined into a versatile installation. The following operations can be performed:

1. Fill Tank A; **2.** Fill Tank B; **3.** Fill Tank C; **4.** Balance levels in Tanks A, B; **5.** Balance levels in Tanks B, C; **6.** Balance levels in Tanks A, C; **7.** Empty Tank A; **8.** Empty Tank B; **9.** Empty Tank C.



Chemical Eng. Bldg. at left; Mechanical Eng. Bldg. at center; Main Research Bldg. at right.

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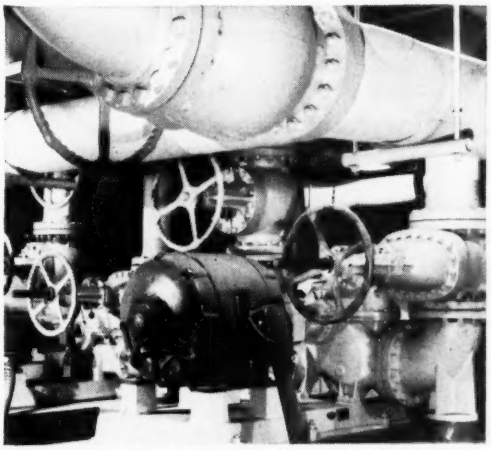

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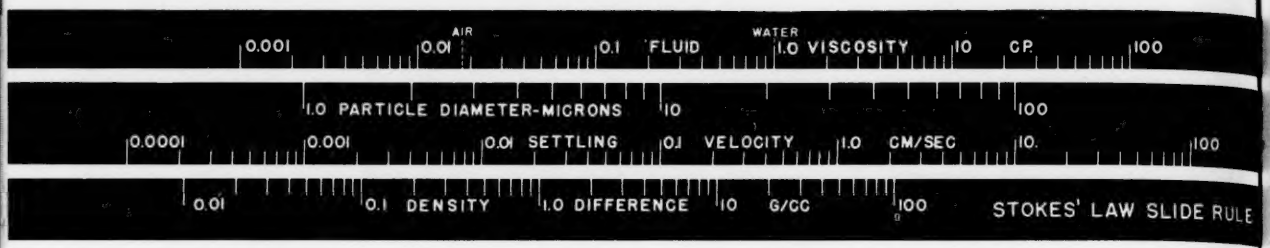

CUT-OUT SLIDE RULE SOLVES STOKE'S LAW CALCULATIONS

A. K. POSTMA
General Electric Co., Richland, Wash.

According to Stoke's Law, the settling velocity of a solid spherical particle is given by

$$V = \frac{d_p^2 \, g \, (\rho_p - \rho_f)}{18\mu} \qquad (1)$$

where V is the particle terminal velocity, cm./sec.; ρ_p is the particle density, gm./cu. cm.; ρ_f is the fluid density, gm./cu. cm.; d_p is the particle diameter, cm.; g is the acceleration due to gravity, cm./sec./sec.; μ is the fluid viscosity, gm./cm. sec.

For convenience, the particle diameter can be expressed in microns, and the fluid viscosity in centipoises, by multiplying by appropriate conversion factors. Taking logarithms of both sides of Eq. (1) gives, after rearrangement,

$$\log (\rho_p - \rho_f) - \log V + 2 \log d_p - \log \mu = 4.264 \qquad (2)$$

In Eq. (2), the particle diameter is expressed in microns, and the fluid viscosity in centipoises. This equation can be solved on a four-scale slide rule as shown. The scales reproduced on this page can be cut out and glued onto an inexpensive slide rule.

The unknown quantity is obtained by aligning the known variables on adjacent sliding scales. The viscosities for air and water at atmospheric pressure and 70 F. are noted on the upper scale.

USE LIQUID SOLDER TO ATTACH BACKING SCREENS

E. C. CURRAN
Kennametal Inc., Latrobe, Pa.

Recently, in the course of conducting screen analyses on tungsten carbide samples, I experienced considerable wear and tear of the test sieves.

In order to strengthen them, the test screens were backed with 20-mesh-screen material. This is a common trick, but the method of attaching the backing material was unusual.

The normal way of attaching this material is to crimp the edges of the backing screen and the test screen together in detachable test sieves. In one-piece test sieves, it is necessary to hot solder the backing screen to the test screen. Both the crimping and hot soldering are difficult operations and require experienced personnel.

The alternate method I devised consisted of preparing the test sieves for a hot soldering by cleaning them with mild acid and then soldering on the backing screen with LePage's liquid solder.

The advantages of the liquid solder over the hot solder in this application are:

- A stronger bond is obtained.
- The bond can be readily built to any size.
- Little or no skill is required.

Another trick to strengthen the test sieves is to solder the very center of the test and backing screens together. The liquid solder, in this case, should cover an area about the size of a dime.

On new screens, if a bead of liquid is built up around the edge of the test screen where it meets the frame, it will lengthen the life of the sieve considerably. This bead should have a width of $\frac{1}{4}$ in. and a thickness of $\frac{1}{32}$ in.

Another use for liquid solder is in repairing torn edges of the test screens. The liquid is particularly better than the hot solder in this application because the weight of the soldering iron can tear the screen further, and the high heat-transfer rate of the metal screen makes hot soldering very difficult. We have used the liquid solder successfully on brass, steel, stainless steel and silk screens.

Test Your CEQ

ROBERT LEMLICH

Is exhaled breath, as it leaves the human body, heavier or lighter than fresh room air at, say, 70 F. and 40% relative humidity?

Answer on page 138.

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Every **Electri-Cand** pump is thoroughly tested before shipment. Performance characteristics are checked. Each unit is hydrostatically tested. Here, Freon #12 is forced into a partially evacuated pump, and a halogen leak detector is used. The pump is rejected if it leaks at a rate of more than one ounce per 100 years. *Electri-Cand* is an Allis-Chalmers trademark.

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AUTOMATIC STEAM SIPHON REVISITED

An article in the June 12, 1961, *Plant Notebook described how a thermostatic steam trap could be used to operate an automatic siphon in a sump pit. The trap would open when the cold water in the sump touched it, and would allow steam to pass through the siphon and pump water out of the pit. When the level fell below the trap, the steam flow would stop.*

All was not as simple as it seemed, however, as the following letter from a reader who tried the device will demonstrate:

Sir:

In your June 12 issue, p. 254, there appears an article entitled "Thermostatic Trap Makes Automatic Steam Siphon."

Our expert crews have spent many hours trying to make this device work without success. It all boils down to this:

The water level rises; the trap starts to heat up the water. The trap opens a little and shoots out condensate and a bit of water. Then the steam hits the trap, it closes and heats up the water in the pit. After a long, long time, the trap opens again and shoots out a little condensate and a tiny bit of water. As the water in the pit continues to warm up, the trap opens less and less until it disappears from sight under the water, where it stays, keeping the water in the pit nice and hot.

What can be wrong with our water? It does not behave like the water in Arkansas.

OWEN BIRD

Montreal East, Que., Canada

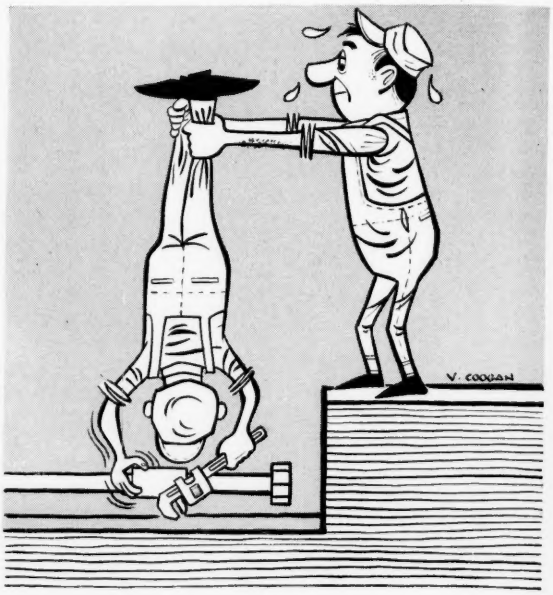
Our initial reaction was to reprint the article under the title "Thermostatic Trap Makes Automatic Water Heater," but we thought better of this and sought the advice of the article's author. His reply follows:

Sir:

Because the physical details of the installation are not given, it is impossible to thoroughly diagnose the problem. However, the experience described in your letter is very much like some of our experiences here at Reynolds. In these instances, it was found that the traps had not been installed upside down as they should be. The instruction sheet enclosed with new traps specifies that the trap be installed with the actuating head up, and it is difficult to impress upon the craftsman the importance of installing the head down in this particular service.

When the head of the trap is down, the rising water comes in contact with the actuating chamber before rising above the steam-supply line. When the water rises above the steam line and remains at that level for a considerable time, as it would when the head is installed up, it is heated to about 212 F. and the siphon becomes virtually inoperative.

Another important point, which we have found insures better performance, is to use the smallest trap



that conditions will allow. Most of our installations use a $\frac{1}{2}$-in. trap and a $\frac{3}{4}$-in. siphon.

M. K. PIERCE

Reynolds Metals Co., Bauxite, Ark.

It is apparent, then, that successful operation of an automatic steam siphon requires an inverted point of view.

Answer to Test Your CEQ

Fresh air consists of about 21% O_2 and 79% N_2 on a dry basis. At 70 F., the vapor pressure of water is 0.36 psia. Thus, the fraction of water vapor present is 0.4 × 0.36/14.7 or 1%. Then, by ideal-gas-law computation, the density of fresh room air is

$$\frac{[(21\times32)+(79\times28)+(1\times18)]\,(460+32)}{101\times359\times(460+70)} = 0.074 \text{ lb./cu.ft.}$$

Of course, this could also be determined from a humidity chart.

Now, exhaled breath normally contains about 4-5% CO_2. Let's call it 4.5%. The O_2 is thus lowered by an almost equivalent amount to about 16.5%. The N_2 content remains virtually unchanged at 79%. These figure are all on a dry basis.

The breath, however, is exhaled at about 98 F., saturated with water. Therefore, the water content is 0.89/14.7 or 6%. Again from the ideal gas law, the density of exhaled breath is

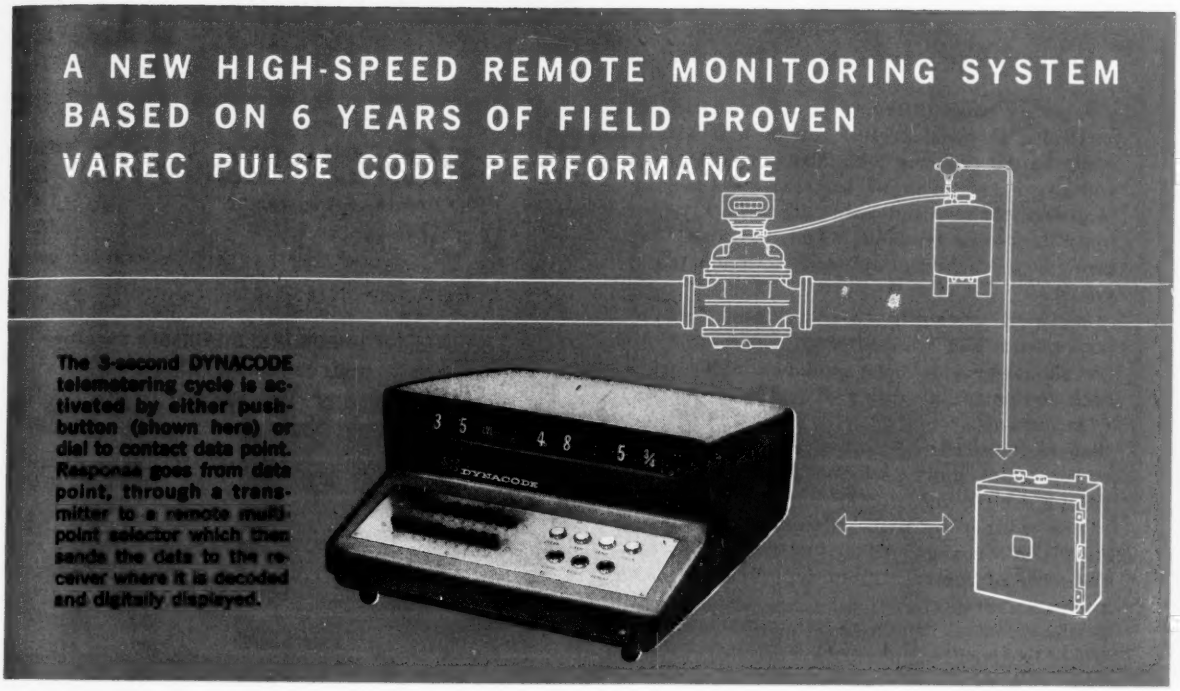
$$\frac{[(4.5\times44)+(16.5\times32)+(79\times28)+(6\times18)]\times(460+32)}{106\times359\times(460+98)} =$$

0.071 lb./cu.ft.

Comparing the two densities, we see that exhaled breath as it leaves the body is several percent lighter than fresh room air.

DYNEL DYNACODE TELEMETERING SYSTEM

A NEW HIGH-SPEED REMOTE MONITORING SYSTEM BASED ON 6 YEARS OF FIELD PROVEN VAREC PULSE CODE PERFORMANCE



The 3-second DYNACODE telemetering cycle is activated by either push-button (shown here) or dial to contact data point. Response goes from data point, through a transmitter to a remote multi-point selector which then sends the data to the receiver where it is decoded and digitally displayed.

Dynel engineers—utilizing the performance proved concepts of Varec's famous Pulse Code system—have developed the significantly advanced DYNACODE telemetering system for remote readings of liquid level, temperature and P.D.M.

This single-channel, "error-proof" system combines the proven reliability of the basic Varec system with a digital readout time of 3 seconds per point... readout accuracy of 1/16 inch... readout capacity of an unlimited number of points... and readout versatility that permits the system to be tied into a general purpose computer for inventory, billing, and similar functions.

Solid state components are used at key points in the receiver design for longer, maintenance-free life. And DYNACODE, like Varec's Pulse Code, has an instantaneous alarm system without scanning delays.

The high-speed DYNACODE System offers these advantages:

Reliability: Design based on 6 years of performance in scores of pipeline and refinery applications.

Data Display: Illuminated, in-line digital display includes point and function identification, digital data to 6 significant figures and liquid level to 1/16" increments.

Fast Response: data from any given point is gathered and digitally displayed in just 3 seconds.

Flexibility: Designed on building block principle that permits a great variety of system arrangements... DYNACODE is compatible with all standard systems of measurement.

Readout Variety: digital output provides a variety of readouts, including visual display, paper tape, typewriter, etc. Output is compatible for use with general purpose computers.

For complete information, see DYNACODE at the ISA Show, Los Angeles Sports Arena – Booth #170. Or write for Bulletin 301, Dept. CHE-I600-3

DYNEL, Inc., *a subsidiary of Varec, Inc.*

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No. 59: Process-Control Instruments

Here's useful purchase-cost data on important elements in process instrumentation: recorders, controllers, and transmitters, for pneumatic and electronic control systems.

B. G. LIPTAK, *Instrument Engineer, Crawford & Russell, Inc., Stamford, Conn.*

Selecting panel instruments and transmitters for a particular chemical process can be a frustrating and somewhat bewildering job. Many factors are involved and a great number of instruments—ranging from recorders, through indicating controllers, to recording controllers—are available. And complicating the picture is availability of pneumatic and electronic systems.

We have attempted to collect cost data on panel instruments and transmitters.* The tables that follow should provide some guidance in the selection of such equipment according to purchase cost.

An automatic controller is defined as a mechanism that measures the value of some variable and operates to correct or limit deviation of this measured value from a desired value.

The manner by which the controlling method responds to a change in the measured variable is called the mode of control. Common modes are on-off, proportional, proportional-plus-reset and 3-mode. Two-position control involves moving the control valve to one of two positions when the controlled variable moves from some set-point. The proportional mode involves a continuous linear relationship between the value of a controlled variable and position of the control valve. The proportional controller has a proportional range (throttling range) that corresponds to the full operating range of the final control element. However, proportional controllers require a manual adjustment to return the variable to the set-point. Proportional-plus-reset instruments are capable of returning the variable automatically to the set-point after some process disturbance.

Miniature Panel Instruments

Because of savings in panel area and equipment cost, miniature panel instruments are widely used in the process industry (Tables I, II).

The miniature instruments listed can measure any variable such as pressure, flow, temperature, level, analysis, etc., since they all receive signals from a transmitter that produces a 3-15 psig. air signal or an electrical signal, regardless of the process variable.

The following question shows how to use Table I: What is cost of a miniature pneumatic recorder-controller with proportional-plus-reset control, one sealed alarm contact and one square-root extractor (the square-root extractor converts a square-root related signal to a linear one)?

Cost from Table I	$540
For sealed alarm contact	52
For square-root extractor	150
Total	$742

Continued on page 142

Costs for pneumatic miniature receiver instruments—Table I

	No Pens	1 Pen	2 Pens	3 Pens
Indicators				
6-in. dial (Fig. 1)	$65	....	....	....
Drum (Fig. 2)	100	....	....	....
Ammeter (Fig. 3)	70	....	....	....
Indicator controllers*				
Proportional (Fig. 4)	...	$310	$330	....
Proportional-plus-reset (Fig. 4)	...	330	350	....
3-mode (Fig. 4)	...	390	410	....
Recorders (Fig. 5)	...	220	300	$385
Recorder controllers* (4-in. strip chart)				
Proportional	...	510	590	....
Proportional-plus-reset	...	540	620	....
3-mode	...	600	680	....
Single-case cascade (Fig. 6)	...	....	1,000	....

Extras, add: $220 for ratio relay (**Fig. 7**); $83 for high or low limit stop relay (**Fig. 8**); $21 for alarm contact; $52 for each sealed alarm contact; $240 for pneumatic integrator (**Fig. 9**); $150 for square-root extractor.

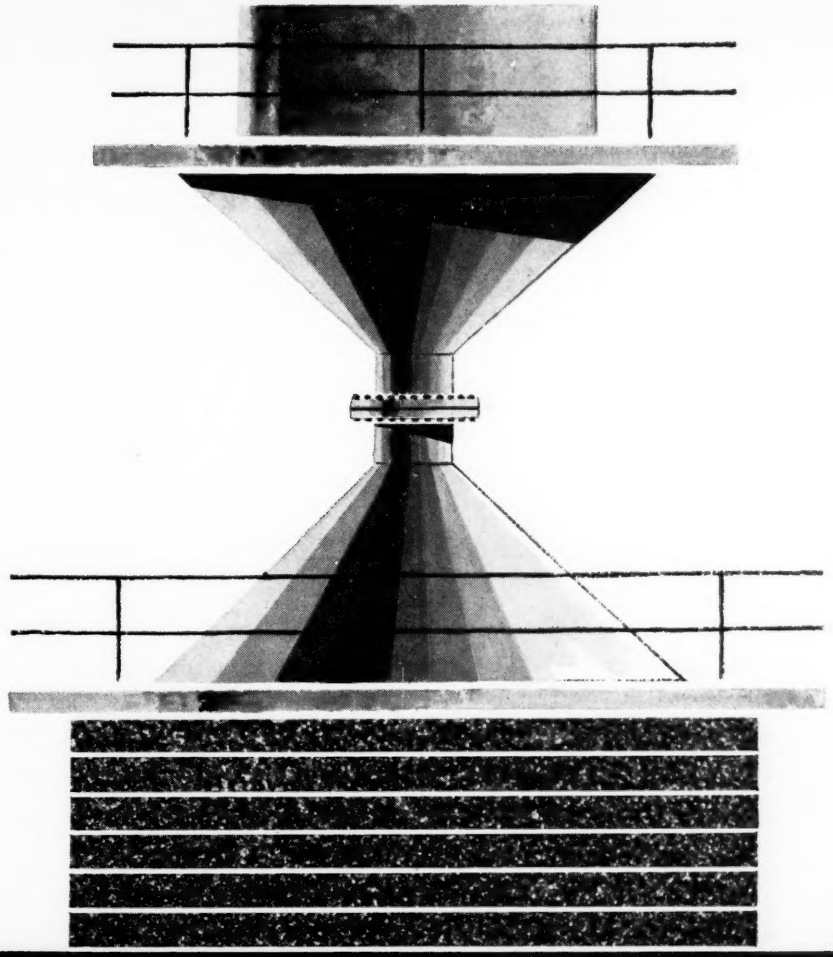
* Set-point transmitter and auto-to-manual transfer station included.

Costs for electronic miniature receiver instruments—Table II*

	No Pens	1 Pen	2 Pens
Indicator controllers			
Proportional-plus-reset (Fig. 21)	$355	...	...
Proportional and fast reset (Fig. 21)	460	...	...
Recorders (Fig. 22)	...	$195	$330
Recorder controllers			
Proportional-plus-reset (Fig. 23)	...	550	685
Proportional and fast reset (Fig. 23)	...	655	790
Single-case cascade (Fig. 21, 23)	...	...	1,150

* Electrical code specification: general purpose.

* For costs of control valves, see Cost File No. 55, *Chem. Eng.*, Aug. 7, 1961, p. 137.



FOAMGLAS® insulation works for Florida's salt water conversion plant

Ironically, the fact that FOAMGLAS insulation *stays* completely dry, impervious to water, is the reason it is important to a new method of water supply that converts ocean salt water to potable water.

The new conversion plant at St. Petersburg, Florida, is the joint effort of Dr. H. F. Wiegandt and Cornell University and Blaw-Knox Company, operating under a contract with the Office of Saline Water, Department of the Interior. The Cooper-Bessemer Corporation and the Florida Power Corporation also participated in this project. The plant utilizes a freezing process and is expected to reach a daily production of 35,000 gallons.

Protecting the piping and equipment is FOAMGLAS, a cellular glass insulation. It provides the constant insulating value necessary in the freeze process plant; it holds check against outside weather and salt air; FOAMGLAS cannot burn, a safety factor since the process uses combustible butane liquid and gas; and FOAMGLAS guards against corrosion since it is water-, moisture- and vapor-proof.

While you may not have a salt water conversion plant like the one shown above, FOAMGLAS can work for you on other industrial insulation applications . . . piping, equipment, vessels, or underground lines. Write for a free copy of our new FOAMGLAS catalog: Pittsburgh Corning Corporation, Dept. H-111, One Gateway Center, Pittsburgh 22, Pa. In Canada: 3333 Cavendish Blvd., Montreal, Quebec.

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Costs for pneumatic transmitters—Table III*

Flow or differential pressure	
Blind (Fig. 16)	$300
Indicating (Fig. 17)	330
Extra for seal-oil-filled system	200
Extra for range below 10-in. H_2O	25
Liquid level	
Flange-mounted diaphragm (Fig. 18)	290
Extra for 300-lb. flange rating	30
Pressure	
Blind (Fig. 19)	160
Indicating (Fig. 17)	180
Extra for chemical seal	50
Temperature (including screwed socket)	
Blind (Fig. 19)	190
Indicating (Fig. 17)	260
Extra for flanged socket	15
Extra for range outside −40 to 800F	20

Extra: add $0.8/ft. for stainless capillary tubing above 10 ft.

* Filter-regulator, sensing element included (orifice plates for flow and liquid level, filled bulbs for temperature, spirals or bellows for pressure).

Costs for electronic transmitters—Table IV*

Flow or differential pressure	
Blind (Fig. 16)	$430
Indicating (Fig. 20)	460
Liquid level	
Flange-mounted diaphragm (Fig. 18)	440
Pressure	
Indicating (Fig. 20)	260
Temperature	
Indicating (Fig. 20)	330

Extra: add $0.8 ft. for stainless capillary tubing above 10 ft.

* Electrical code specification: Class I, Group D, Div. II. Costs include converter, amplifier and sensing element (orifice plates for flow and liquid level, thermocouples or resistance bulbs for temperature, spirals or bellows for pressure).

Costs for pneumatic, full-size, direct-connected, indicating controllers—Table V*

Pressure	
On-off (Fig. 10)	$295
Proportional (Fig. 10)	380
Proportional-plus-reset (Fig. 10)	445
Flow or differential pressure	
On-off (Fig. 10)	340
Proportional (Fig. 10)	450
Proportional-plus-reset (Fig. 10)	510
Temperature (including screwed socket)	
On-off (Fig. 12)	290
Proportional (Fig. 10)	440
Proportional-plus-reset (Fig. 10)	520
3-mode (Fig. 10)	580
5-in. dial, remote, does not control, (Fig. 11)	60

* Cost of sensing element included. For pressure, element is Bourdon tube or bellows; for temperature, it's filled thermal bulb; for differential pressure or flow, bellows or mercury manometers. Also included: filter-regulator.

Extras (apply to Tables V and VI), add: $65 for manual-automatic subpanel; $40 for diaphragm chemical seal; $90 for absolute-pressure instrument; $30 for ambient temperature compensated unit; $15 for flanged thermowell; $0.8/ft. for stainless capillary tubing above 20 ft.

Costs for pneumatic, full-size, direct-connected recording controllers—Table VI*

	1 Pen	2 Pens	3 Pens	4 Pens
Pressure				
On-off (Fig. 14)	$300	$450	$560**	...
Proportional (Fig. 14)	390	625	735**	...
Proportional-plus-reset (Fig. 14)	460	750	860**	...
Recorder only (Fig. 13)	160	210	250	360
Flow or differential pressure				
On-off (Fig. 14)	350	550	...	...
Proportional (Fig. 14)	445	725	...	...
Proportional-plus-reset (Fig. 14)	505	855	...	...
Recorder only (Fig. 13)	200	300	...	...
Temperature (including screwed socket)				
On-off (Fig. 14)	370	575	....	...
Proportional (Fig. 14)	460	755	...	...
Proportional-plus-reset (Fig. 14)	525	885	...	...
3-mode (Fig. 14)	575	985	...	...
Recorder only (Fig. 13)	220	330	440	550
Potentiometer				
Multipoint strip-chart recorder, up to 24 points, (Fig. 15)	...	...	...	1,500

* Costs include sensing element (see Table V), filter-regulator, three-months supply of 12-in. circular charts and ink.
** Controls two pressures and records the third.

Tables III and IV list costs for pneumatic and electronic transmitters. This equipment is required whenever it is necessary to measure a particular variable where the measurement point is at a considerable distance from the controller. In the case of pneumatic transmission, the controlled variable is converted to air pressure by the transmitter. This pressure is conducted through a tube to the receiver (usually a panel instrument). The same principle applies to electronic equipment.

Example: What is cost of an indicating-temperature transmitter with flanged thermowell and 40 ft. of tubing?

Cost from Table III	$260
Flanged socket	15
Tubing (30 x 0.8)	24
Total	$299

Pneumatic Vs. Electronic

There is a definite trend in the chemical process industries toward electronic control instruments. But advantages of electronic over pneumatic equipment are not clear-cut. Some pros and cons are:

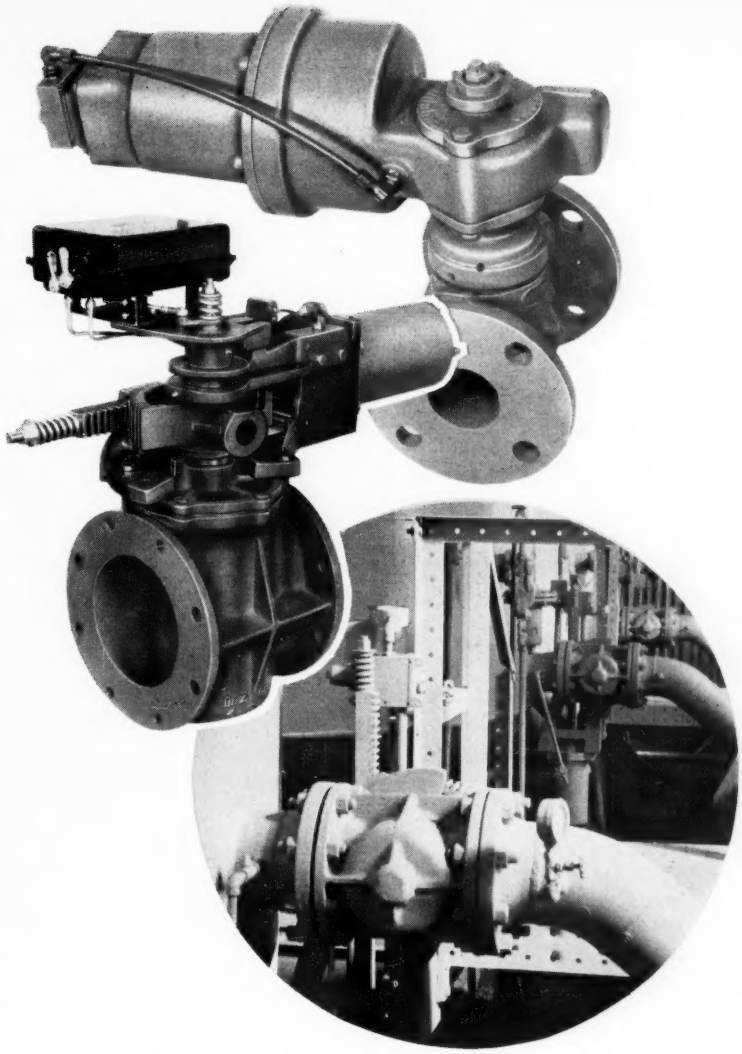
Cost of Installation—(1) Where signals travel > 300-500 ft., electronic systems cost less to install. (2) For explosion-proof service, costs may favor pneumatic systems.

Maintenance—(1) Electronic systems are remarkably free of trouble. (2) A disadvantage of electronic equipment is loss of control if power fails and standby power is not available. (3) Climatic conditions can

HIGH ALLOYS AT LOW COST

...IN DeZURIK "CUSTOMIZED" CONTROL VALVES

DeZurik Control Valves provide superior specific protection from corrosive media — protection that can be "tailor-made" in High-Alloy Control Valves.



VALVE BODIES OF THESE HIGH ALLOYS:

ALLOY 20 — HASTELLOY B
HASTELLOY C — MONEL
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Your "customized" DeZurik Control Valves are the only valves that give you DeZurik ECCENTRIC-ACTION—friction-free and non-binding *without lubrication*. Permanently easy-operating, with minimum wear, minimum care. Almost unlimited flow characteristics—you change the curve simply by changing a cam in the positioner.

And you pay LESS for DeZURIK HIGH-ALLOY CONTROL VALVES! Their high capacity often permits use of a smaller-size valve with no reduction in flow but with positive reduction in initial cost PLUS the virtual elimination of maintenance costs!

DeZurik Control Valves are available with all types of actuators, in sizes from ½" thru 30".

ASK FOR BULLETIN 150

DeZURIK Corporation
Sartell, Minnesota
DeZURIK OF CANADA, LTD. Galt, Ontario

put pneumatic systems at a disadvantage (freezing air lines).

Flexibility—For adding, multiplying and squaring, the electronic system is more flexible.

Response Speed—Electronic instruments control deviations from the set-point much faster than pneumatic controllers (narrow proportional band).

Converter—Electrical output signal to the control valve is normally converted to a pneumatic signal at the valve. Converter cost is $90, but it also serves as a valve positioner.

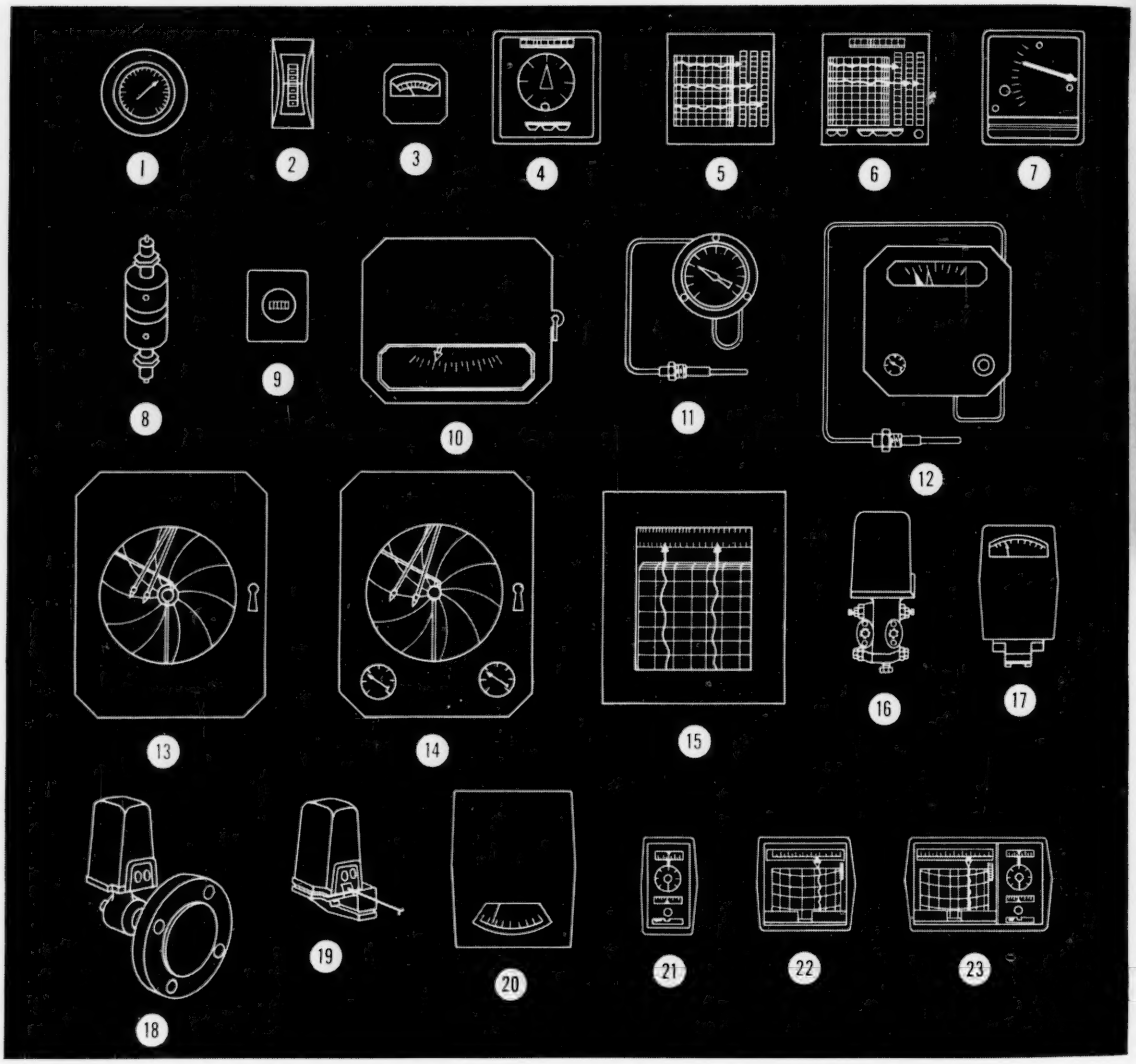
Tables V and VI give cost information on full size, pneumatic, direct-connected instruments. These are used when it is not necessary to send the process signal back to the control room. Direct-connected, full-size instruments are not yet used with electronic actuating signals.

Example: What is cost of single-pen, three-mode, temperature-recording controller with manual-automatic subpanel and 20 ft. of stainless tubing?

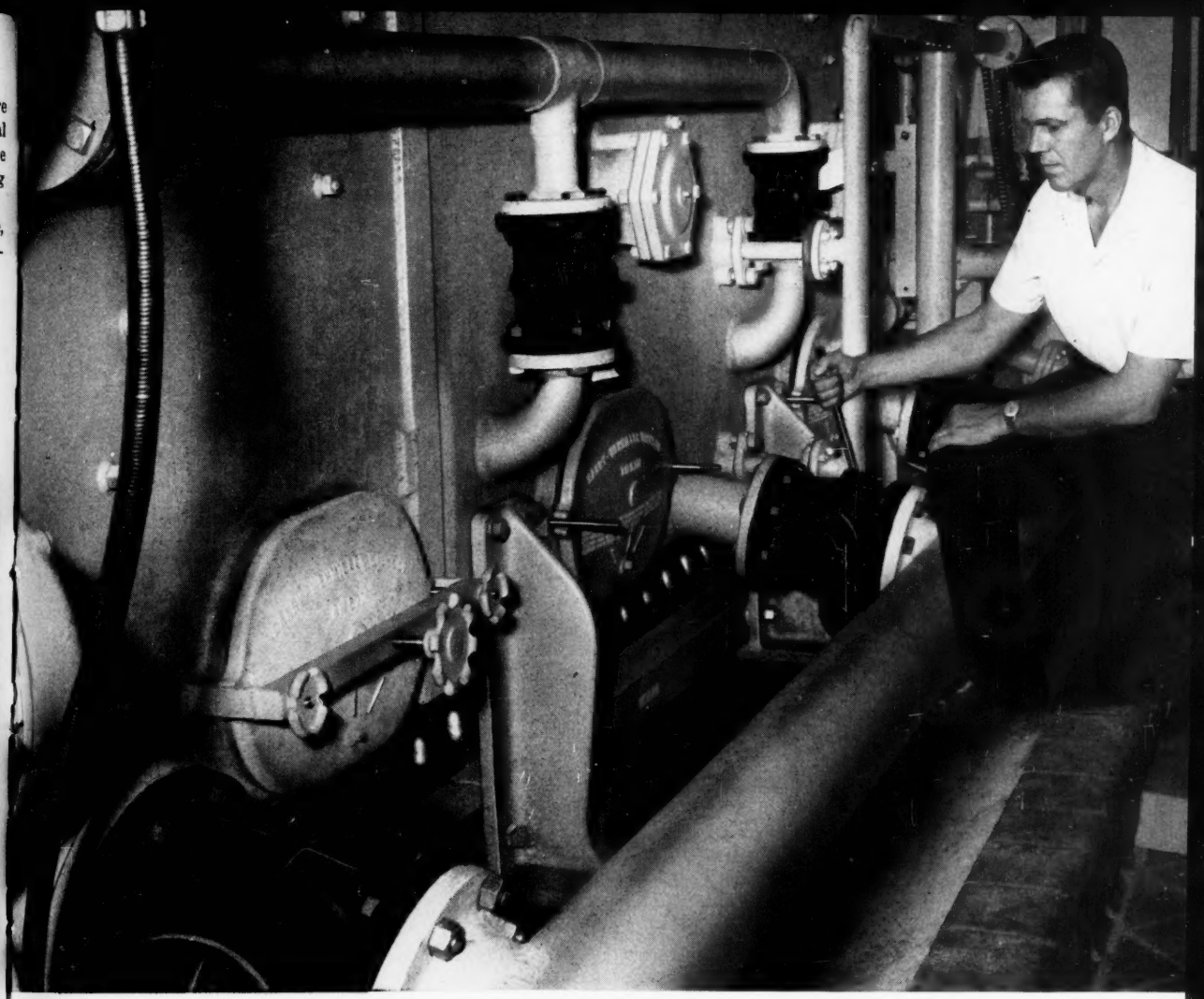
From Table VI	$575
Manual-automatic subpanel	65
Total	$640

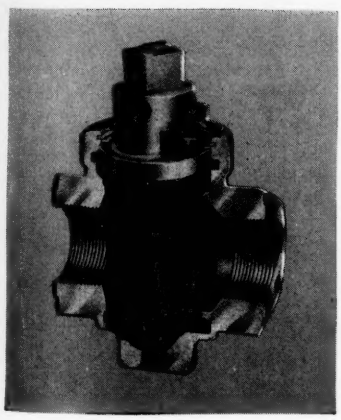
All costs are based on March 1961 data.

Panel instruments and transmitters: variety and complexity



Miniature pneumatic—dial **(Fig. 1)**, drum **(Fig. 2)**, ammeter **(Fig. 3)**, indicator controller **(Fig. 4)**, recorder **(Fig. 5)**, recorder controller **(Fig. 6)**, ratio relay **(Fig. 7)**, stop relay **(Fig. 8)**, integrator **(Fig. 9)**. Full-size pneumatic—indicating controller **(Fig. 10)**, dial **(Fig. 11)**, on-off **(Fig. 12)**, recorder only **(Fig. 13)**, recorder controller **(Fig. 14)**, strip-chart recorder **(Fig. 15)**. Pneumatic transmitters—blind **(Fig. 16)**, indicating **(Fig. 17)**, diaphragm **(Fig. 18)**, blind pressure **(Fig. 19)**. Electronic transmitters—pressure or temperature indicating **(Fig. 20)**. Electronic instruments—indicator controller **(Fig. 21)**, recorder **(Fig. 22)**, recorder controller **(Fig. 23)**.





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W-K-M ACF Non-Lubricated EC Plug Valve

Many valves were tried for the tough job of controlling the flow of a caustic washing solution that often contained bits of bottle glass and labels, but W-K-M's EC Plug Valve was the only one that could do the job successfully.

We admit this is a problem you don't run into every day, but it's a good indication of the effectiveness of the W-K-M EC Plug Valve. Whatever type of service this valve is applied to it gives a tight seal that can be adjusted on the line when wear develops. Further it excels in the handling of solid bearing liquids or gases since its elastomer coated plug resists even severe abrasive action. The W-K-M EC Plug Valve requires no regular maintenance since it is non-lubricated.

Write for specification sheet AE-1061 for full details.

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18-in.-dia. column can be mounted without strengthening roof.

Plastic Scrubbers Control Air Pollution

Light weight and excellent corrosion resistance of polyester packed-columns offer significant economies.

FRED W. ARNDT, *Heil Process Equipment Corp.*

With the increasingly stringent attitude of both state and municipal authorities toward air pollution, and the growing emphasis on community relations, more and more plants are faced with substantial expenditures for pollution-control equipment.

This type of equipment normally does not contribute to production and profit (and actually involves an expense with no hope of monetary recovery), so a company will usually select the cheapest installation that meets operating requirements. As a result, particularly where corrosives are involved, there has been a recent trend toward the use of scrubbers, ducts and fans constructed from reinforced polyester, a material contributing to high over-all economy and effectiveness.

A number of factors determine the cost of the control system. The initial purchase price of a fume scrubber may be misleading when used as the sole basis of comparison. Cost of installation is also significant, as is the time required to pack the column. Other factors influencing the cost of the equipment include the degree of maintenance required and anticipated service life.

Weight of the unit and its accessories is also important, particularly in elevated positions, because excessive weights may require additional costs to strengthen the supporting structural members.

Using these criteria, reinforced-polyester units compare favorably with metals. In general, reinforced-plastic packed columns are easily installed. Initial purchase price is moderate, generally lower than equivalent lined-steel or alloy equipment. Polyesters, particularly the type based on bisphenol A resin, offer excellent resistance against acids, alkalis, bleaches, and a number of organic solvents that are commonly encountered (Table I). Maintenance, painting or scraping costs are almost negligible. Scrubbers made of this material are also extremely light in weight and offer

specific design for low cost maintenance

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DURICHLOR
CHLORIMET 2
CHLORIMET 3
DURCON
DURCO D-10
DURIRON
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18-8-S-Mo
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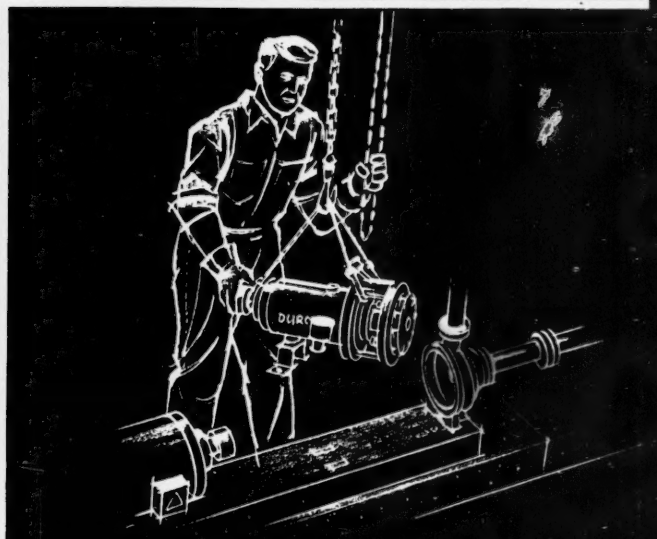
TITANIUM

Fourteen alloys for any corrosive service

Interchangeable parts: 1 bearing housing + 1 shaft = 10 pumps



One man—one craft to remove all rotating parts

Is pump "down-time" increasing your operating expense?

Why disconnect motors and process piping when making pump repairs? The Durco Series "H" pump is designed for complete servicing by one craft to speed maintenance and cut costs.

Why inventory a multitude of bearing, housing, shaft and seal sizes? One set of these is interchangeable on Durco "H" pumps with capacities from 10 to 750 GPM and TDH from 10 to 350 ft.

Why be "short changed" on corrosion resistance? Durco leads in the development and manufacture of corrosion resistant alloys. Castings are designed for optimum corrosion resistance and hydraulic efficiency and are produced in our own foundry to assure complete quality control from raw material to finished pump.

Why settle for less than Durco? Durcopump's hydraulic efficiency combined with the right alloy and rugged, heavy duty bearing and shaft design provide long life and low operating cost.

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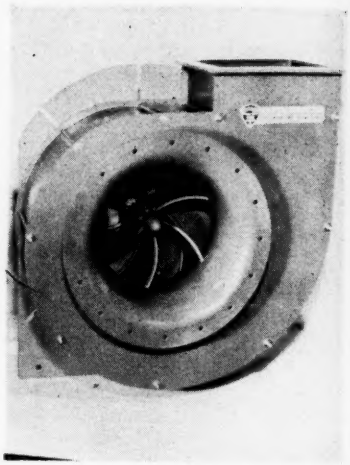
THE DURIRON COMPANY INC., *Dayton, Ohio / Serves the process industries*

DURCO

outstanding advantages for roof-mounted installations.

►**Weight Advantages**—Reinforced-polyester structures are usually constructed without metals. A typical structure consists of glass-reinforced polyester, and the packing support grid may be constructed from polyester, polyvinyl chloride, high-density polyethylene, or some other plastic. The internal water-distribution system as well as the entrainment separator are fabricated completely from plastic to eliminate the need for metals. Weight of a reinforced-polyester scrubber is approximately one-sixth to one-third that of a lined-steel unit (Table II).



Plastic fans also reduce roof load. Such fans are especially desirable where fumes are highly corrosive.

The added weight of accessory equipment such as ductwork, fan, stack, and water-recirculation pump or treatment tank, is also a factor. If composed of heavy-weight materials, this equipment will add substantially to the roof load. Frequently, the pumps and water-circulation or treatment tanks are mounted indoors below the roof to decrease the load.

Another method for decreasing weight involves use of the receiver section of the scrubber to serve as the water-treatment or recirculation tank. This design eliminates the need for an extra tank, and only adds the weight of the water in the receiver to the roof load. In a 5-ft.-dia. scrubber, for example, this would add the weight of 245 gal. or 1,850 lb. to the loading.

Heavy-duty reinforced-plastic fans are also employed in some special applications to reduce roof loading further (Table III). In some size ranges, the weight reduction is negligible because of the larger dimensions of the plastic fans and the weight of their steel bases and motor-mounting arrangements. However, the excellent corrosion resistance of the solid-plastic impeller and housing

Resistance of Reinforced Bisphenol Polyester to Typical Corrosive Fumes—Table I

Corrodent	Not Attacked	No Apprec. Attack	Slight Attack	Attacked	Not Recommended
Acetic acid	C M H				
Acetone	C M H				
Acrylonitrile		C	M	H	
Alcohol, amyl	C M H				
Alcohol, benzyl	C	M	H		
Alcohol, butyl	C M H				
Alcohol, ethyl	C M H				
Alcohol, methyl	C M H				
Ammonia, aqueous	C M	H			
Amyl acetate	C	M	H		
Aniline sulfate	C M H				
Barium chloride	C M H				
Barium hydroxide	C M	H			
Barium sulfide	C M H				
Benzene	C	M	H		
Butyl acetate	C	M	H		
Carbon disulfide	C	M		H	
Carbon tetrachloride	C	M		H	
Chlorine	C M H				
Chlorobenzene	C	M	H		
Chromic acid	C M H				
Diethyl ketone	C M		H		
Ethyl acetate		C	M	H	
Ethylene chlorohydrin	C M H				
Ethylene glycol	C M H				
Ethylene dichloride		C	M	H	
Formaldehyde	C M H				
Furfural	C	M		H	
Gasoline	C M H				
Heptane	C M H				
Hydrochloric acid	C M	H			
Hydrocyanic acid	C M H				
Hydrogen peroxide	C M				
Hypochlorite bleach	C M	H			
Methyl ethyl ketone	C M				
Naphtha	C M H				
Nitric acid	C M	H			
Perchlorethylene		C	M	H	
Phenol	C	M		H	
Phosphoric acid	C M H				
Phosphorus trichloride		C		M	H
Pyridine		C		M	H
Sodium hydroxide	C	M	H		
Sulfur dioxide	C	M	H		
Sulfuric acid	C M	H			
Sulfuric acid, fuming		C	M	H	
Toluene	C	M		H	

Note: C, under 80 F., M, 80—160 F.; H, 161 F to boiling.

ECONOMICS OF BONDSTRAND®

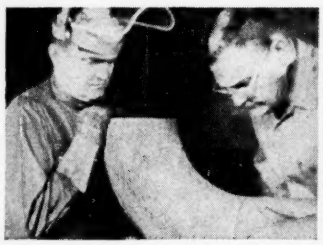
...used for corrosive chemicals

A 20′ length of 6″ schedule 40 carbon steel pipe weighs 398 lbs. Crane required for lifting.

A 20′ length of 6″ Bondstrand pipe weighs only 60 pounds. One man can lift and carry.

Cutting steel pipe takes four (or more) times longer than Bondstrand.

Bondstrand is cut with ordinary hacksaw. Preheating not required.



Two men required to bevel, clean, position, center and level a 90° elbow before welding.

Only one man required to apply adhesive and position a 90° Bondstrand elbow. It aligns itself.

Welder and helper required to tack weld, check alignment, make stringer weld and grind, make flush weld and grind again, make cover weld, grind and wire brush.

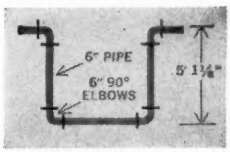
One man with a hammer and a two-by-four makes the Bondstrand Quick-Lock joint in a matter of seconds. Important: **Bondstrand pipe may be handled immediately; no waiting for adhesive to cure.**

IT TOOK 65 MINUTES TO WELD ONE ELBOW TO STEEL PIPE. ONE MAN MADE THE SAME ASSEMBLY WITH BONDSTRAND IN ONLY 10 MINUTES!

BONDSTRAND, the fiber glass reinforced epoxy pipe, handles nearly every corrosive solution—acids, salts, alkalies—used in industry today. It will withstand pressures up to 550 psi and temperatures up to 300°F. So will the complete line of BONDSTRAND fittings, 2″ through 12″.

The smooth, abrasion-resistant inner surface permanently retains its excellent flow characteristics (Hazen-Williams formula C=150) and thus often permits use of one-size-smaller diameter pipe. BONDSTRAND is only one-eighth the weight of steel and because it resists exterior as well as interior corrosion it does not require continual maintenance painting.

BONDSTRAND versatility is unmatched by any other pipe—metallic, thermoplastic, glass or lined. What does this superiority cost? Less than you may suspect. Here is how BONDSTRAND compares with carbon steel in this simple pipe layout:



TOTAL COST OF MATERIAL AND LABOR

Schedule 40 **Carbon Steel** Pipe With Welding Elbows **$225.63**

Series 4000 **Bondstrand** Pipe With Bondstrand Elbows **$287.40**

Figures shown are from a strict time-and-cost study conducted by one of Southern California's leading independent piping and engineering firms.

This means that in this layout you get all the advantages of BONDSTRAND for only 21.7% more than ordinary carbon steel pipe. (In complex process piping, BONDSTRAND can actually cost less.) In Schedule 40 stainless steel, which approximates BONDSTRAND's chemical resistance, the layout would cost $1,287.50—*348% more than* BONDSTRAND!

To evaluate the superiority of BONDSTRAND *pipe for your specific requirements, write for complete technical data.*

Amercoat® CORPORATION 138

111 Colgate Ave., Buffalo, N. Y. | 2404 Dennis St., Jacksonville, Fla. | 6530 Supply Row, Houston, Tex.

Weight Comparisons

Plastic and Steel Packed-Columns—Table II

	Lined-Steel Shell; Stoneware Packing	Lined-Steel Shell; Plastic Packing	Plastic Shell; Plastic Packing
Shell[1]	2,685 lb.	2,685 lb.	360 lb.
Packing	4,220 lb.[2]	735 lb.	735 lb.
Internal supports	1,180 lb.	610 lb.	255 lb.
Total weight	8,085 lb.	4,030 lb.	1,350 lb.

[1] 13-ft. high X 5-ft dia.; [2] 1-in. saddles, 5½-ft-high bed.

Plastic and Steel Fans—Table III

	Weight, Lb.
Plain steel (heavy-duty construction)	835
Rubber-lined steel	910
Coated steel	860
Solid-plastic impeller and housing	620

All fans are 6,000 cu. ft./min., 2–4-in. static pressure range, including 7½-hp totally enclosed fan-cooled, 1,800 rpm. motor.

20-in.-Dia. Ducts—Table IV

Material	Weight, Lb./Ft.
Plain steel, 16-gage, galvanized	13
Coated steel, 16-gage, 40-mil coating	14.6
Rubber-lined steel, 16-gage, ⅛-in. lining	16.5
Stainless steel, 16-gage	13
Rigid polyvinyl chloride, ⅛-in. thick	5.5
Glass-reinforced polyester, ⅛-in. thick	5.5
Cement-asbestos composition	32.5
Stoneware	65
Marine plywood,[1] ½-in. thick, good 2 sides, AA exterior type	10.5

[1] Rectangular equivalent of 20-in. dia.

often makes it desirable for the more severely corrosive fumes. Use of reinforced-plastic ducts will also radically decrease weight of the fume-exhaust equipment.

▶ **Additional Costs**—In one plant, a costly arrangement was required to avoid reinforcing the roof and sacrificing plant floor space. The scrubber, made from lined steel, was mounted on a platform over the process equipment. The upper part of the column protruded through a hole in the roof. In addition to providing savings in floor space, this partially in-plant arrangement eliminated winter freeze-ups within the unit. The fan, stacks and ductwork were fabricated of plastic and located on the roof. If a low-weight reinforced-plastic scrubber were available at the time of this installation, roof-mounting would have eliminated the scrubber platform and large roof breaching.

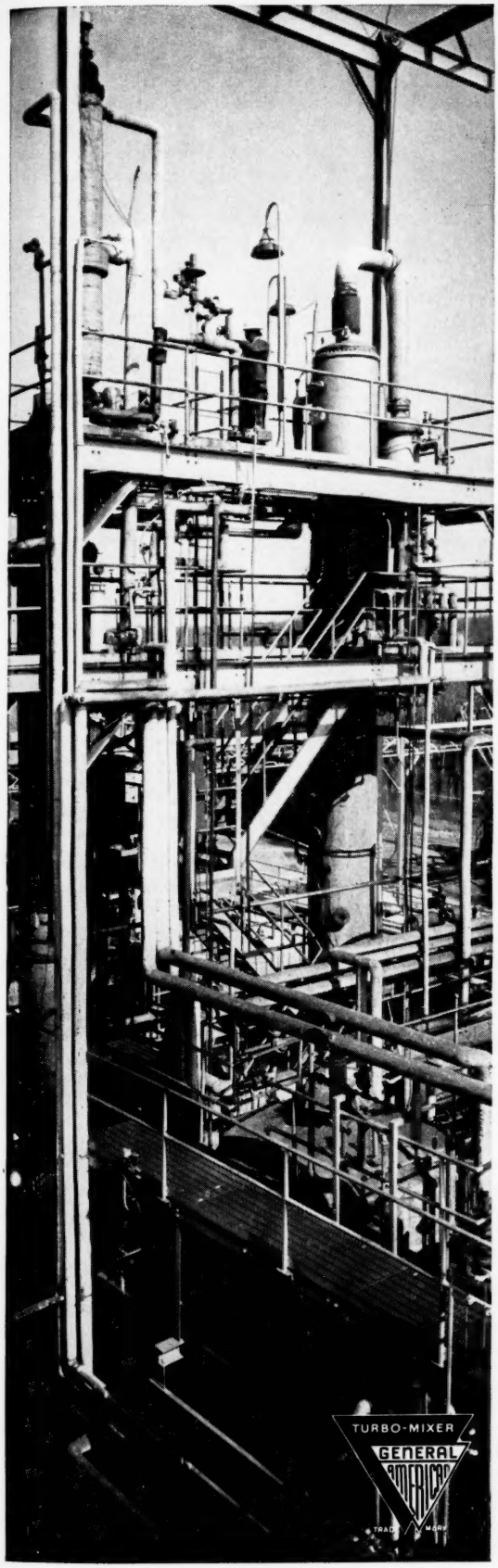
▶ **Corrosion Resistance** — Resistance to corrosion is one of the primary reasons for fabricating a scrubber from reinforced polyester. The shell should be resistant to both the removed fumes and the scrubbing liquid. Particularly resistant is a specialty polyester resin, Atlac 382, based on bisphenol A. Comparative tests made on this material at Atlas Chemical Industries, Inc., have shown that it will withstand a wide number of extremely corrosive media at elevated temperatures.

▶ **Location of Scrubber**—Availability of production space will affect the placement of the scrubber and accessory equipment. If the process location allows the scrubber to be mounted outdoors at ground level, the expense is generally not great. Often, however, the production area is far from an outside wall of the plant, and the cost of running ductwork for this distance may be prohibitive. This situation or the lack of ground-level outdoor space may require a roof installation and consequent careful consideration of equipment weight.

▶ **Maintenance Schedule**—Maintenance schedules and practices are also factors to be considered. In many plants, there is a tendency to neglect preventive maintenance for roof-mounted equipment because it is not easily accessible—and it is also easily overlooked because it is out of the way. As a result, the remotely located scrubber will probably become the object of corrective rather than preventive maintenance. It is vital, therefore, that the equipment be designed for mechanical soundness and extreme corrosion resistance, to keep maintenance costs to a minimum.

Meet the Author

FRED W. ARNDT *is chief engineer for Heil Process Equipment Corp., Cleveland. He is a chemical engineer with B.S. and M.S. degrees from Stevens Institute of Technology. He is a member of the AIChE (Past chairman of Cleveland Section) and the Air Pollution Control Assn.*



TRY THIS SIMPLE QUIZ ABOUT THE **RDC** COLUMN

1. *R.D.C. stands for*

- ☐ a) Rapid Dispersion Column
- ☐ b) Recycle Displacement Column
- ☐ c) Rotating Disc Contactor

2. *RDC Columns are made by*

- ☐ a) 6 different manufacturers
- ☐ b) by one manufacturer
- ☐ c) by 10 manufacturers

3. *The RDC column has been used for*

- ☐ a) Separation of Hafnium from Zirconium
- ☐ b) Caustic extraction of acids from organics
- ☐ c) Caffein and vanillin extraction

4. *The RDC column can be used for*

- ☐ a) liquid-liquid extraction
- ☐ b) liquid-solid extraction
- ☐ c) liquid-slurry extraction

5. *The RDC column has which of these advantages*

- ☐ a) High volumetric efficiency
- ☐ b) No interstage coalescing or external settling
- ☐ c) Low power requirements

Answers

1. (C) Rotating Disc Contactor.

2. (B) RDC columns are made for the process industries exclusively by General American, and on a non-exclusive basis for the petroleum industry.

3. (A), (B) and (C). For a complete list of typical systems in service, contact General American.

4. (A), (B) and (C) again. The RDC column is one of the most versatile tools available for extraction processing.

5. (We did it again—all three are correct).

It you'd like more information on the RDC column and the many advantages it offers, send for Bulletin T-1159. You'll find it pays to plan with General American.

Process Equipment Division—Turbo-Mixers
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 3, Illinois
Offices in principal cities

Need a tasteless, odorless, colorless gum with lack of syneresis?

TRY METHOCEL

Methocel® methylcellulose offers unique combinations of properties found in *no other gum*. It serves as a stable thickener, binder and bulking agent. Food manufacturers are particularly interested in this tasteless, odorless, colorless gum that offers lack of syneresis—that is, prevents undesirable separation of water from the food product. Methocel is also thermo-gelling.

Send for a sample of Methocel.
See pages 158 & 159 for details.

DOW

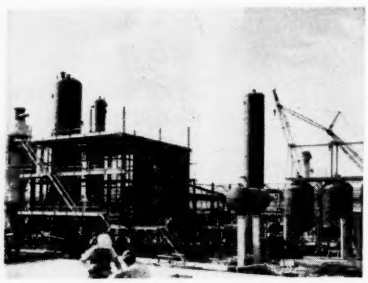
THE DOW CHEMICAL COMPANY
Midland, Michigan

Continued from page 66

will be used captively. Construction by Brown & Root, Inc., is to begin late this year, with completion scheduled for a year later.

Air Reduction Pacific Co., a division of Air Reduction Co., Inc., will add a $1-million, high-purity hydrogen unit to its Richmond, Calif., industrial gas plant. To feed on natural gas, the installation will include a hydrogen-purification step that utilizes the properties of palladium, in a process said to be the first of its kind in commercial use on the West Coast. With construction starting soon, completion of project is expected by next April.

Climax Chemical Co., a recently formed firm, has awarded an engineering and construction contract to Leonard Construction Co., for a 150-ton/day Leonard-Monsanto contact sulfuric acid plant near Hobbs, N. M. Expected to be completed by next summer, facility will be fed hyrogen sulfide and sulfur.



Armour Agricultural Chemical Co. reports that construction of its $25-million fertilizer complex at Cherokee, Ala., is progressing on schedule (*Chem. Eng.*, May 29, p. 124). Shown above is the 360-ton/day ammonia plant, which is expected to be in full-scale operation by the middle of next March. Other facilities going up include a 500-ton/day ammonium phosphate unit and a 300-ton/day nitric acid plant.

El Paso Natural Gas Products Co. and **Rexall Chemical Co.** have started up the ethylene unit at their joint petrochemical complex in Odessa, Tex. Full 150-million-lb./yr. capacity is expected to be reached later this month. Ethylene product is being stored at the site until an adjacent 200-million-lb./yr. polyethylene plant is ready for startup, probably in early December.

Standard Oil Co. of California's Western Operations, Inc., hopes to have Alaska's first oil refinery on stream by mid-1963, and possibly as early as the end of 1962. The 20,000-bbl./day installation will be built on the Kenai Peninsula, costing an estimated $10 million (*Chem. Eng.*, June 26, p. 74).

Owens-Corning Fiberglas Corp. has dedicated a multimillion-dollar technical center at Granville, Ohio. Research facilities are provided for more than 200 technologists.

Offices

The Permutit Co., a division of Pfaudler Permutit Inc., will move its headquarters from New York to Paramus, N. J., next February.

Atomic Energy Commission will establish an area office in Palo Alto, Calif., to administer its $114-million Stanford University linear accelerator project.

Abbott Laboratories has moved its Philadelphia area branch office to King of Prussia, Pa. New branch provides office, warehouse and receiving facilities.

Companies

Chas. Pfizer & Co. has acquired **New England Lime Co.** and its subsidiaries, including Nelco Metals, Inc., for approximately 313,000 shares of Pfizer common stock. In the announcement, Pfizer hinted at plans to "substantially increase" New England Lime's capacity at Adams, Mass., and Canaan, Conn.

Enjay Chemical Co., a division of Humble Oil & Refining Co., has tentatively agreed to acquire Ex-

trudo-Film Corp., a producer of polyethylene and polypropylene film. Extrudo-Film stockholders must approve the agreement.

FBA Pharmaceuticals Inc., New York, has been created "as an autonomous unit" of West Germany's Farbenfabriken Bayer AG., Leverkusen. Firm will develop, produce and market pharmaceutical specialties in the U. S.

Air Products and Chemicals, Inc., has bought 160,000 shares of **Houdry Process Corp.** stock from Sun Oil Co., simultaneously offering one share of its own stock for every share of Houdry owned by the remaining Houdry stockholders. Air Products' transaction with Sun included cash payment for 80,000 shares, and a one-for-one exchange of Air Products stock for the other 80,000 Houdry shares owned by Sun.

International

India has signed an agreement with ENI (Ente Nazionale Idrocarburi), Italy's state-owned oil and gas monopoly, for construction of a $120-million pipeline, refinery and petrochemical complex. The deal had been in doubt (*Chem. Eng.*, Sept. 18, p. 228), due to "serious objections" raised by India's Finance Ministry to ENI's itemized stipulations as originally presented (*Chem. Eng.*, Sept. 4, p. 172). Under the agreement, $100 million represents cost of equipment from Italy, $20 million is value of Indian materiel and labor.

Japan: Tokuyama Soda has placed a 2,000-ton/yr. polypropylene plant on stream, with production scheduled for expansion to 10,000 tons/yr. by mid-1963, and 20,000 tons/yr. by mid-1964. Guardedly, firm says only that it "developed its own technology."

West Germany: Union Rheinische Braunkohlen Kraftstoff A.G. will build a cracking plant at Wesseling, near Cologne, to produce 70,000 tons/yr. of ethylene and undisclosed tonnages of propylene by the end of 1963. Bulk of the output is reported to have been signed for by Farbwerke Hoechst A.G.'s wholly owned subsidiary, Knapsack-Griesheim A.G., which will use the ethylene to replace acetylene in acetaldehyde production.

Italy: At the recent Milan stockholders' meeting of ANIC, the petrochemical affiliate of Ente Nazionale Idrocarburi (ENI), ENI president Enrico Mattei announced that his firm's now-abuilding Gela refinery would cost $192 million; ANIC's Ferrandina petrochemical project, about $56 million. Complete rundown of products slated for the Gela refinery (in metric tons/yr.): petroleum products, 1.4 million; ammonium sulfate, 165,000; urea, 100,000; ethylene, 50,000; polystyrene, 25,000; ethylene oxide, 20,000 (chiefly for captive glycols production); ethylene glycol and ethanolamine, 18,000 (mainly for on-site manufacture of polyester resins, synthetic fibers, and antifreeze); and synthetic glycerin, 10,000.

As for the Ferrandina complex, currently planned outputs (also in metric tons/yr.) are: methanol, 70,000; vinyl acetate monomer, 20,000; monomeric acrylonitrile, 5,000; and acrylonitrile fibers, 5,000.

Canada: Allied Chemical Canada, Ltd., has announced plans for the nation's first diisocyanates facility, a multimillion-dollar plant to be built in Ontario province. Completion is scheduled for late next year. Company won't yet name site, capacity or specific products.

El Salvador: Fertica de Panama S.A.'s Salvadoran affiliate plans a $5-million facility at Acajutla, to produce ammonium phosphate and ammonium sulfate fertilizers. Articles of incorporation for the firm were signed Sept. 30, after a year of on-again, off-again negotiation. Ground will be broken within three months; construction will take 18 months more.

Japan: Showa Denko K.K. plans to produce polypropylene and

Looking for a thickening gum that's surface-active, viscosity-stable?

TRY METHOCEL

There's a Methocel® product for almost any thickening use, in almost any viscosity range. Surface-active Methocel is used as an excellent emulsifier, emulsion stabilizer and protective colloid. Easily soluble in water and/or organic solvents, Methocel methylcellulose can simplify the formulating and production of many kinds of products. For example, latex paints, pharmaceuticals, foods, chemical specialties, construction materials.

Send for a sample of Methocel.
See pages 158 & 159 for details.

DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan

Interested in a protective colloid with water and/or organo-solubility, as you wish?

TRY METHOCEL

Choose from over 50 different products of Methocel® methylcellulose to get the exact degree and kind of solubility your process requires. You can also select from a wide viscosity range . . . 2% solutions range from 10 to 15,000 centipoises. Surface-active Methocel is an excellent thickener, protective colloid, and suspending agent. Suspensions are stable and uniform over long periods of time. Methocel is resistant to the growth of microorganisms.

Send for a sample of Methocel.
See pages 158 & 159 for details.

DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan

stereosymmetric propylene polymers under Tennessee Eastman Co. licenses. Licensing agreement has been signed, but Japanese government must approve the project. Apparently, facilities would be added at the firm's Tokyo chemical complex.

Thailand: Thai Oil Refinery Co. has signed a contract with the Thai government for construction of a $35-million oil refinery, to process 40,000 bbl./day of crude at Bangkok. Facility will be taken over by the government in ten years. Construction will begin this month, be completed within two years. Thai Oil Refinery Co. is a Thai-owned group but is "supported" by ten international concerns, including Shell, Caltex and Stanvac.

Japan: Ube Kosan plans an $8.3-million plant at Goi, Chiba prefecture, to produce 13,000 tons/yr. of *cis*-polybutadiene and *cis*-polyisoprene by Sept. 1963. A fifteen-year license has been taken from B. F. Goodrich Co., under the terms of which Ube Kosan will pay a flat $500,000, plus royalties of 3% and 2½% respectively on sales of *cis*-polybutadiene and *cis*-polyisoprene.

Canada: St. Lawrence Columbium and Metals Corp. plans to begin producing columbium concentrate later this month at a $2-million, automated facility in Oka, Que. Capacity will be 500 tons/day, readily expandable to 2,000 tons/day. The Oka mine and mill are said to be the first in North America; currently, most columbium is imported in limited quantities from Africa.

Belgium: Cities Service Co., New York, has indirectly entered the European Common Market via the acquisition of a "substantial" interest in Ammoniaque Synthetique et Derives (ASED), a subsidiary of Evence Coppee & Cie, Brussels. ASED makes nitrogen fertilizers, coke and chemicals near Antwerp.

Mexico: Zincamex, S.A., newly created by the state-held Mining Development Commission (CFM), will own and operate a 30,000-ton/yr. metallic zinc refinery to be built and financed by Syndicat Belge d'Entreprises a l'Etranger (SYBETRA). Construction of the $12.5-million facility will begin next year at Saltillo, Coahuila state, with startup of the first furnace scheduled for April, 1964. Unit will process an annual 60,000 tons of zinc concentrate into 30,000 tons of metal, boosting the country's metallic zinc capacity by 60%. (Currently, about 400,000 tons/yr. of concentrate are produced. Of this, American Smelting & Refining Co. processes 100,000 tons into 50,000 tons of zinc metal at its Nueva Rosita, Coahuila, plant. Remaining 300,000 tons of concentrate are exported to the U. S.)

People

William C. Quinn has been designated director of engineering for Fairmount Chemical Co.

James M. Blakely has been elected vice president of engineering and operations for Sonic Development Corp. of America. Until recently, he was assistant to the president of Dayco Corp.

Sam Webb, Jr., is the new vice president of operations for Atlantic Cement Co. He assumes responsibility for production of raw materials and control of manufacturing operations and distribution facilities.

Albert V. Crewe has been named director of Argonne National Laboratory, which is operated by University of Chicago for the AEC.

Franklin L. Dailey has been named manager of development for Pittsburgh Chemical Co.'s Activated Carbon Div.

John A. King has been appointed manager of research and development for American Cyanamid Co.'s Agricultural Div., and **Nolan B. Sommer** has been named general manager of the firm's Central Research Div.

Convention Calendar

December

3-6. American Institute of Chemical Engineers, 54th Annual Meeting, Hotel Commodore, New York, N. Y.

3-7. American Institute of Electrical Engineers, Institute of Radio Engineers, Assn. for Computing Machinery, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C.

4-6. Chemical Specialties Mfg. Assn., Roosevelt Hotel, New York, N. Y.

5-6. Western Petroleum Refiners Assn., Refiners Computer Conference, Hotel Tulsa, Okla.

6-8. American Institute of Mining, Metallurgical and Petroleum Engineers, Iron & Steel Div., 19th Annual Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

7-8. Society of the Plastics Industry, 9th Plastic Film, Sheeting & Coated Fabric Conference, Pierre Hotel, New York, N. Y.

7-8. American Chemical Society, Combined Southwest & Southeast Regional Meeting, Jung Hotel, New Orleans, La.

12-14. Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C.

18-19. Rensselaer Polytechnic Institute, Materials Research Conference, Troy, N. Y.

26-31. American Assn. for the Advancement of Science, Annual Meeting and Exposition of Science and Industry, Denver Hilton Hotel, Denver, Colo.

January

9-11 American Society for Quality Control, American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn., National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D. C.

12-15. American Institute of Mechanical Engineers, Annual Meeting, New York, N. Y.

22-25. National Plant Maintenance and Engineering Show, Convention Hall, Philadelphia, Pa.

23-26. Canadian Pulp & Paper Assn., 1962 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Can.

26-2. American Management Assn. Quality Control, AMA Academy, Saranac Lake, N. Y.

31-2. University of California, Gas Chromatography Course, Los Angeles, Calif.

February

5-9. American Society for Testing Materials, Committee Week Meeting, Statler-Hilton Hotel, Dallas, Tex.

6-8. Society of the Plastics Industry, Reinforced Plastics Div. Conference, Edgewater Beach Hotel, Chicago, Ill.

12-15 12th National Exposition of the Air-Conditioning, Heating and Refrigeration Industry, Great Western Exhibit Center, Los Angeles, Calif.

18-22. American Institute of Mining, Metallurgical & Petroleum Engineers, Annual Meeting, New York, N. Y.

21-23. Oklahoma State University, National Gas Conference, Stillwater, Okla.

March

1. Drug, Chemical & Allied Trades Assn., 36th Annual Dinner, Waldorf-Astoria Hotel, New York, N. Y.

4-7 American Society of Mechanical Engineers, Gas Turbine Power Conference & Exhibit, Shamrock-Hilton Hotel, Houston, Tex.

13-14. Manufacturing Chemists' Assn., 2nd Symposium of Packaging of Chemical Products, Chase-Park Plaza Hotel, St. Louis, Mo.

14-16. Instrument Society of America, 12th Annual Conference on Instrumentation for the Iron & Steel Industry, Hotel Roosevelt, Pittsburgh, Pa.

15-23. American Society of Tool & Manufacturing Engineers, Engineering Conference and Exhibit, Cobo Hall, Detroit, Mich.

19-23 National Assn. of Corrosion Engineers, Annual Conference and Show, Municipal Auditorium, Kansas City, Mo.

18-22. National Assn. of Corrosion Engineers Meeting, Municipal Auditorium, Kansas City, Mo.

20-29. American Chemical Society, National Meeting, Washington, D. C.

April

9-10. Instrument Society of America, 4th National Chemical & Petroleum Instrumentation Symposium, Wilmington, Del.

Want a nonionic bulking agent . . . compatible with heavy metal salts and alkaline earth elements?

TRY METHOCEL

Methocel® methylcellulose offers valuable combinations of properties unavailable in any other gum, natural or synthetic. For example, nonionic Methocel is compatible with a wide range of materials, and it is not precipitated as an insoluble salt by multivalent metal ions. In addition, Methocel is used as an excellent film former, binder, thickener. Viscosity stability is excellent over a pH range from about pH 3 to 12.

Send for a sample of Methocel.
See pages 158 & 159 for details.

DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan

Looking for a low-ash, thermo-gelling binder safe for human consumption?

TRY METHOCEL

Colorless, tasteless, odorless Methocel® methylcellulose products are available in grades for use in foods and pharmaceuticals. They are ideal binding and thickening agents and are not metabolized when ingested. Ash content is negligible. Methocel is also unique in that it is thermo-gelling, a property of great value in helping control water migration in food and pharmaceuticals. And because Methocel is surface-active, it is an effective emulsion stabilizer.

Send for a sample of Methocel.
See pages 158 & 159 for details.

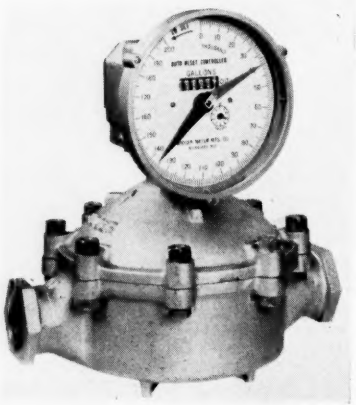
DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan

Continued from page 78

A temperature-sensing probe that fits through an opening in the magnet's center is spring-loaded to insure positive contact with the surface.

The magnet may be moved from surface to surface without disconnecting the couple from recording instruments. Conductor wires are available in any length, including the standard 12-in. Covered by a stainless steel braided sheath, the wires are available in either Chromel-Alumel or Iron-Constantan, to be compatible with indicating and/or recording meters.—**The Advanced Products Co., North Haven, Conn.** **78E**



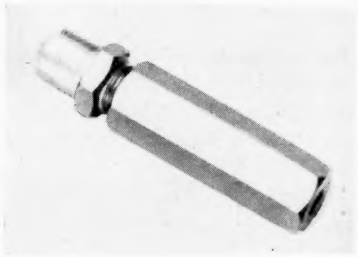
Controlled meter

Unit delivers predetermined flow of liquid, then resets automatically

If checking the softness of water from a conditioner—to find when to switch softening units—is a tedious job, try this automatic reset controller that meters a predetermined amount of liquid, then resets itself for the next cycle. Between cycles, it sends out a signal that starts the regeneration cycle on automatic systems.

The total amount of liquid metered in each cycle can be fixed anywhere from 1 to 100% of full dial capacity, which can range from 20,000 to 1 million gal. Two pointers show both the preset value and how many gallons still have to be metered in the cycle.

If more than one water softener is being used, the coil of a built-in relay can be wired into the control circuit so that no more than one tank will be regenerated at any particular time. The preset value can be changed at any time with an adjusting screw.—**Badger Meter Mfg. Co., Milwaukee.** **156A**



Excess-flow check valve

When flow exceeds a preset rate, a spring-loaded poppet shuts quickly.

Sudden failure of a pipe or tubing that handles hazardous or toxic material will not be a problem with this excess-flow check valve. When flow-through exceeds a predetermined rate, a spring-loaded poppet in the valve shuts instantly.

After the downstream rupture has been sealed and the system recharged to normal pressure, the valve resets automatically, and normal flow is restored. The unit may be coupled directly to a pressure tap on a pressure system, or installed between the system and instrument lines connected to flow meters or other instruments.

Containing only two moving parts, the device may be used for complete closure or to allow a very slow, calibrated leak.—**Chemiquip Co., New York.** **156B**

Resin proportioner

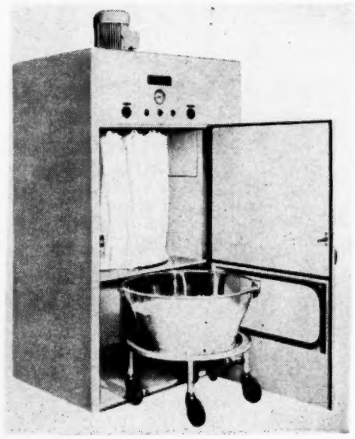
Positive-displacement pumps control resin and hardener input rates.

Application of highly viscous epoxy formations is simplified with a device that meters resin and hardener before they are mixed with filler material.

The unit consists of two electrically driven positive-displace-

ment pumps that proportion resin and hardener in the desired ratio. These materials are delivered to a mixer-extruder where filler material is introduced. The flow rate of all three components is adjusted to yield the desired formulation.

A screw mixes and extrudes the compound, ready for use. The mixer, driven by an adjustable-speed electric drive, can be set to deliver from 1 to 10 lb./min. The mixing chamber is accessible for easy cleaning, or sand can be circulated for cleaning without disassembly. Formulations with up to 400% filler have been compounded and extruded.—**G. Diehl Mateer Co., Wayne, Pa. 156C**



Fluid-bed dryer

Heated air passes through material in batch or continuous operations.

Hot air fluidizes and dries solid particles in this dryer that is said to speed up batch-drying operations. Loads of from 11 to 440 lb. may be dried in 30 min. or less.

In operation, material to be dried is placed in a container having a bottom of fine-mesh screen. The container fits into a carriage that is rolled into the dryer, where the container is lifted against a frame to form a dust-tight seal.

Air, heated by passage over steam coils or electric heaters, is pulled up through the charge, aerating the product for maximum surface exposure of the particles. Moisture-laden air passes up through a bank of nylon filter tubes, through a fan, and exits through a damper that may be adjusted to control air volume. Larger units have automatic shakers for the filter sleeves.

Uniform drying and minimized production of fines are also cited as advantages of the mechanism. It can be adapted for continuous operation.—**The Fitzpatco Corp., Chicago. 157A**

Briefs

Chlorine indicator continuously analyzes treated water, registers any change in residual chlorine within 10 sec. Sensitive to 0.01 ppm., the device may be used to indicate only, or indicate, control chlorinator output.—**Wallace & Tiernan Inc., Belleville, N. J. 157B**

Pipe fittings, agitators, thermowells, valves, and even tanks, may be coated with corrosion-resistant plastics such as Penton, Kel-K and Teflon. Coatings are applied to equipment supplied by vendors or users.—**General Plastics Corp., Bloomfield, N.J. 157C**

Equipment Cost Indexes . . .

	June 1961	Sept. 1961
Industry		
Avg. of all	236.9	237.2
Process Industries		
Cement mfg.	230.9	231.1
Chemical	237.3	237.7
Clay products	224.4	224.6
Glass mfg.	224.0	224.4
Paint Mfg.	229.4	230.3
Paper mfg.	228.6	229.0
Petroleum ind.	234.8	235.2
Rubber ind.	237.6	238.1
Process ind. avg	235.2	236.2
Related Industries		
Elec. Power equip	235.1	235.8
Mining, milling	238.7	239.2
Refrigerating	268.6	269.1
Steam power	225.0	225.5

Compiled quarterly by Marshall and Stevens, Los Angeles, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; Mar. 6, 1961, pp. 115-116 for annual averages since 1913.

Want a colorless, inert gum to form strong, water-soluble films?

TRY METHOCEL

Methocel® methylcellulose forms tough, flexible, clear, cold-water-soluble films. They're grease and oil resistant, with good ink holdout. Or perhaps you want a thickener, binder or water-retention agent. Whatever the use, you'll find the best *combination* of gum properties in Methocel. There are over 50 products to choose from, for use in almost every kind of product from paint to pharmaceuticals, from cosmetics to concrete.

Send for a sample of Methocel.
See pages 158 & 159 for details.

DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan

TRY METHOCEL FOR ALL THESE GUM PROPERTIES...

thickener–film former–binder–stabilizer –thermal gelling–water retention agent

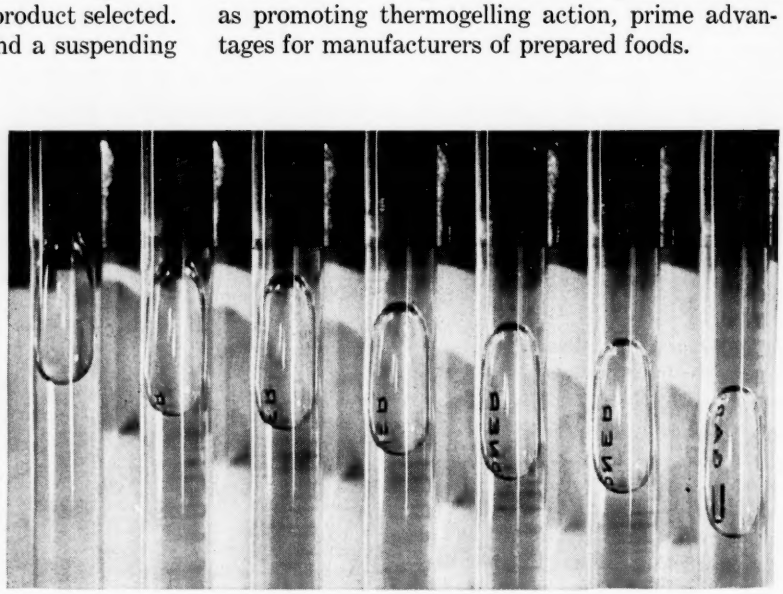
This family of over 50 Methocel® products offers unique combinations of properties where thickening and/or a number of other actions are required. Methocel methylcellulose is soluble in both cold water and organic solvents. Available viscosities range from ten to 15,000 centipoises in 2% solutions, depending on the Methocel product selected. It's a film former, an emulsifier and a suspending agent for almost any kind of water-based product. And because Methocel is nonionic, solution viscosity is highly stable. Colorless, tasteless, odorless Methocel products are available in grades used in pharmaceuticals and food products as an acceptable food additive. They exhibit lack of syneresis as well as promoting thermogelling action, prime advantages for manufacturers of prepared foods.

SOLUBILITY

You can select the degree or type of solubility you need. Methocel products are available which possess solubility in water and in organic solvents. Solubility can thus be varied to meet product requirements.

VISCOSITY STABILITY

Viscosities of the various Methocel products range from ten to 15,000 cps. Because they are nonionic, the viscosity of solutions is stable over a wider pH range than other gums, i.e., from about pH 3 to 12. Methocel is very resistant to the growth of microorganisms. Normally it does not require the addition of preservatives.



Methocel offers a full range of viscosities.

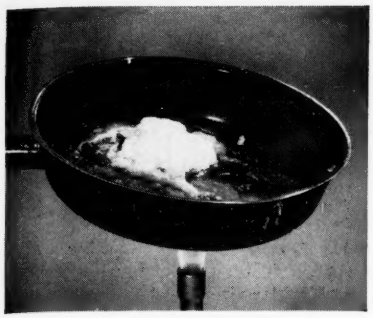
THERMAL GELATION

Solutions containing certain types of Methocel gel on heating or cooling in contrast to other gums which gel only on cooling. This unique phenomenon is reversible. This is particularly valuable for adhesives which must set up on heating.

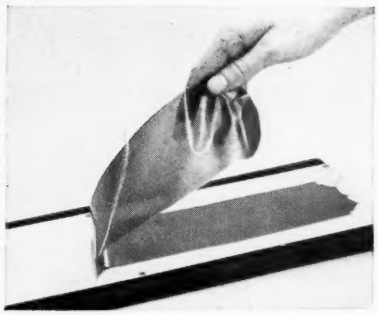
Where thermal gelling is a disadvantage, other types of Methocel are available which do *not* exhibit this property.

STRONG FILM FORMER

Methocel can form tough, flexible, clear, water-soluble films which are



Solutions of Methocel gel on heating.



Tough, water-soluble films can be made with Methocel.

resistant to grease and oil, and can be heat sealed. In addition, they provide good ink, varnish and wax holdout for certain applications. Low viscosity types of Methocel are used to obtain maximum solids. Because specific gravities of the films are low, they usually give superior binding properties or greater area coverage per pound than other gums.

STABILIZER

All Methocel products are effective stabilizers and protective colloids. Choice of the type to be used depends on the application because protective colloid effects can be very specific both as to type and viscosity. Operating temperatures must also be considered, since thermal gelation properties can be an important factor.

WATER RETENTION

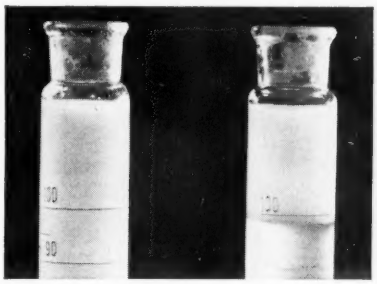
This property of Methocel is particularly valuable to the food manufacturer. When used as a binder, Methocel exhibits lack of syneresis. Foods do not weep water. In certain types of foods Methocel retards drying out of products, keeping them moist and saleable over long periods of time.

SURFACE ACTIVITY

Unlike other gums, solutions of Methocel are surface active, reducing the surface tension of water solutions. Methocel is used as a very effective emulsifying and suspending agent.

BINDING AGENT

Methocel products are excellent binders for all kinds of pigments, glass fibers, fillers, colors, toxicants. Being nonionic, Methocel products have a wide range of compatibility with other formulating ingredients.



Methocel forms stable suspensions.

WIDE PRODUCT RANGE

The many varying combinations of properties offered by Methocel products are highly advantageous for agricultural compounds, chemical specialties, cosmetics, pharmaceuticals, paints, foods, paper products, textiles and others.

Send for free samples and information on Methocel products. Be sure to include a brief description of your requirements or product on the coupon.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan

THE DOW CHEMICAL COMPANY
Abbott Road Building • Midland, Michigan • Attn: Chemicals Merchandising Dept. 690AK11-27

Please send me Methocel Handbook and a sample of Methocel, of the type most suitable for the specific product or application described below.

_____

_____

_____

Viscosity range desired_____ Solubility ☐ water ☐ organic

Name_____ Title_____

Company_____

Company Address_____

City_____ Zone_____ State_____

WAGNER®
MOTORS
AT
WORK

power to make ammonia

100 hp Wagner® explosion-proof motor provides safe, all-weather drive for gas reform induced draft fan

The motor: a totally-enclosed, fan-cooled Wagner Type JP-1. It's the perfect power package for the fan it drives in the Phillips Pacific Chemical Corporation plant at Kennewick, Washington. It is completely explosion-proof—protected against dust, dirt, abrasives and fumes, and is capable of operating for long periods under critical conditions without maintenance.

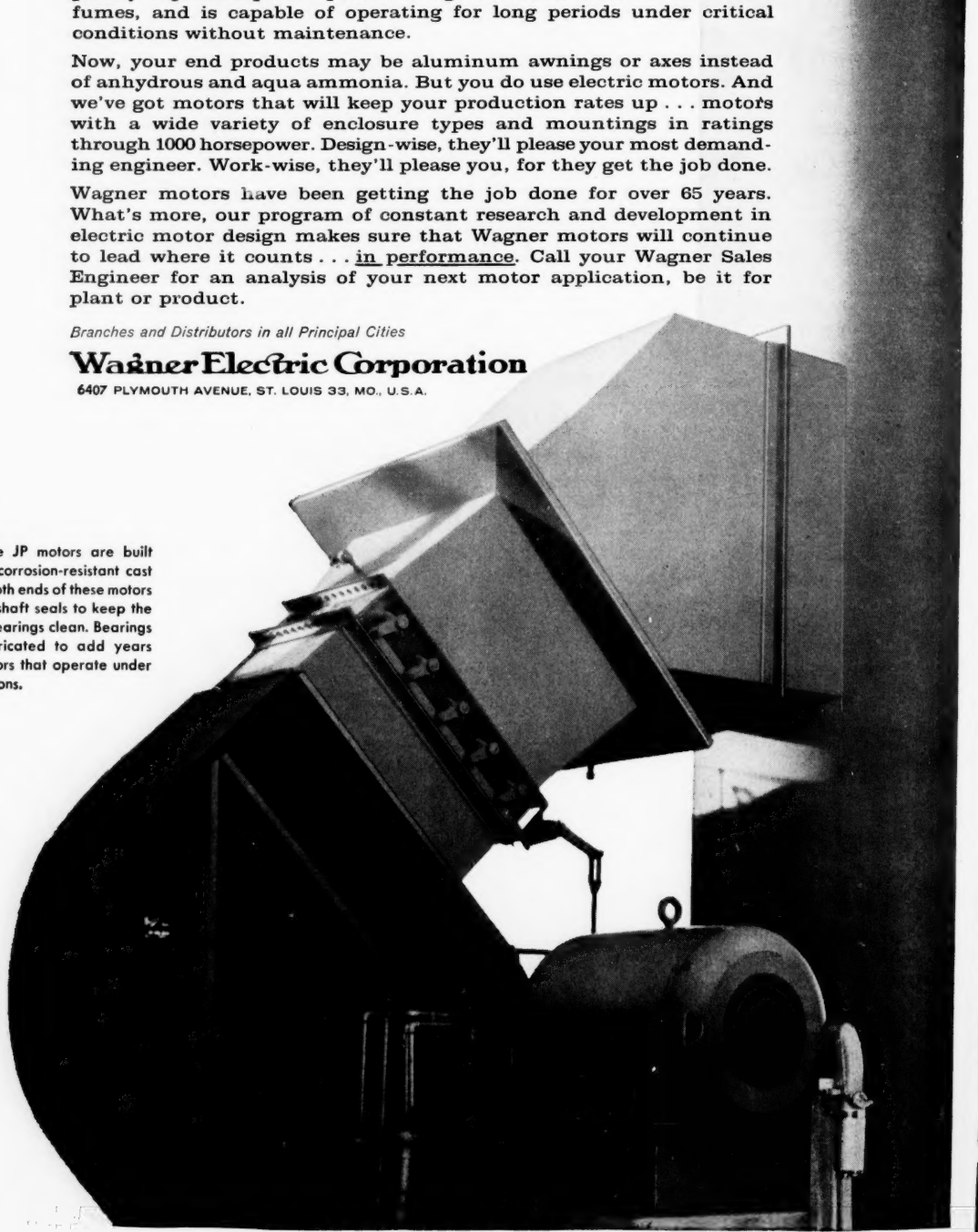
Now, your end products may be aluminum awnings or axes instead of anhydrous and aqua ammonia. But you do use electric motors. And we've got motors that will keep your production rates up . . . motors with a wide variety of enclosure types and mountings in ratings through 1000 horsepower. Design-wise, they'll please your most demanding engineer. Work-wise, they'll please you, for they get the job done.

Wagner motors have been getting the job done for over 65 years. What's more, our program of constant research and development in electric motor design makes sure that Wagner motors will continue to lead where it counts . . . in performance. Call your Wagner Sales Engineer for an analysis of your next motor application, be it for plant or product.

Branches and Distributors in all Principal Cities

Wagner Electric Corporation

6407 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U.S.A.



Wagner Type JP motors are built with rugged, corrosion-resistant cast iron frames. Both ends of these motors have running shaft seals to keep the heavy-duty bearings clean. Bearings can be relubricated to add years to life of motors that operate under severe conditions.

WH61-9

Technical Bookshelf

A SEARCH FOR WORDS

INFORMATION RETRIEVAL AND MACHINE TRANSLATION. PART I OF TWO PARTS. ED. BY A. KENT. INTERSCIENCE. 686 PAGES. $23.

Reviewed by B. E. Holm, Engineering Service Div., Engineering Dept., E. I. du Pont de Nemours & Co., Inc.

This is the first part of a two-volume work that records the papers and discussions of the International Conference for Standards on a Common Language for Machine Searching and Translation, held under the auspices of Western Reserve University and the Rand Development Corp., Sept. 6-12, 1959. This volume includes the papers presented on machine literature searching.

The conference had two chief purposes.

One was to convene most of the notables in the field of documentation and have them present papers on current work.

The other was to begin work toward the adoption of standards in the field of information storage and retrieval, including machine translation. Since this volume treats the former subject only, I shall restrict my comments to the technical papers included in the book, and not comment upon the goals and results of the conference.

The book includes 22 chapters, representing 21 papers given. About half the papers are theoretical reviews of what might be done. Some of these are based upon unproved hypotheses and are of questionable value.

Chapter 1 is the major chapter, taking up 236 of the 686 pages. It is divided into six tables (with short introductions) listing literature searching devices, information systems, machine translation programs, language pairs under investigation, subject fields covered in machine translation, and translation equipment. These provide extensive listings of who is doing what in these fields. The problem is that this material is already out-of-date. Such references can generally be found in National Science

Doré's FLUOROGREEN E-900, scientifically compounded FEP Teflon*, provides outstanding resistance to the corrosive action of acids, alkalis and many other solvents that attack steel pipe. It cannot contaminate any line products, has a very low adhesive characteristic for minimum flow resistance and is practically impervious to erosion. FLUOROGREEN E-900 has less porosity and better chemical inertness than extruded TFE (Teflon) or Teflon 100.

Specify FLUOROGREEN lined piping systems to handle severe products . . . to protect against corrosion and contamination . . . to avoid the fragility found in non-metallic piping. A FLUOROGREEN E-900 system will withstand operating temperatures to 350°F. Lined pipe is supplied in lengths to 10 feet with 150 lb. ASA flanges. The tees and ells are standard, cast ductile iron fittings with 150 lb. ASA flanges. Pipe and fittings are available in sizes 1″, 1½″, 2″, 3″, 4″ and 6″.

If corrosion and/or contamination is a problem write for Data Sheet E-900 or ask for name and address of your nearest distributor.

* Registered trademark of E. I. Du Pont Co. for their fluorocarbon resins including TFE resins.

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BOOKSHELF . . .

Foundation publications such as "Nonconventional Technical Information Systems in Current Use" and "Current Research and Development in Scientific Documentation." Each of these publications, for less than $1 each, would seem to be a better buy because they are revised regularly and therefore are more current.

The other chapters range from classification studies by S. R. Ranganathan and S. Parthasarathy, through machine literature searching and chemical nomenclature studies by V. P. Cherenin and A. M. Zuckermann of the U.S.S.R. to reviews of specific systems such as the Minicard Film Record, the Magnacard System, and the GE-250 Information Searching Selector. This last piece of equipment, after a long dissertation on its virtues, is given a footnote to the effect that its features would be more compatible with advanced circuitry and storage methods. Therefore, the information searching equipment delivered to Western Reserve University was the GE-225, a general-purpose computer.

In summary, this book is a compilation of papers by international authorities in the field of documentation. There is no noticeable continuity throughout. This is certainly not a book for chemical engineers interested in a general review of the field of information retrieval. The book is highly specialized, often narrowly theoretical, and in many areas, already out-of-date. It is doubtful that it is even of interest to many documentalists.

In Rapid Review

The Condensed Chemical Dictionary. 6th ed. Ed. by A. and E. Rose. Reinhold. 1,257 pages. $17.50. Many changes have been made in this first new edition since 1956. Page size is enlarged to 6⅝ × 9¾ in., with number of pages also increased. Much information on rockets and thermonuclear phenomena is included. Scads of new trademarked items make their first appearance, while older, established ones are often amplified with information on new uses. One indication of growth: manufacturers listed at front of book numbered 355 in 1956; now the total is over 450. What has not changed is the over-all excellence of the dictionary. For A to Z information on chemi-

cals, materials, properties, grades, synonyms, and so on, there's hardly need to go further than this one source.

Handbook of Thermophysical Properties of Solid Materials. Vols. I-V. Ed. by A. Goldsmith, T. E. Waterman, and H. J. Hirschhorn. Two publishers have brought out competing editions of the same five-volume, 4,300-page reference work. The texts of the two editions are identical (and so are the prices), but The Macmillan Co.'s set is hardbound, while Pergamon Press Inc.'s publication is looseleaf-bound. Pergamon says that its binding thus facilitates the handy addition of new data as it becomes available. But when pressed, the publisher also admits that it has "no present plans" to issue supplements of new data, though the idea hasn't been ruled out as "valuable," especially "in two years or so." On the other hand, Macmillan's edition is handsome, fine and slick in appearance, printed on quality paper—but hardbound, so can't be supplemented in case new data does become available. Either way, the contents represent all published data on 12 of the major properties (density, melting point, specific heat, thermal conductivity and diffusivity, emissivity-reflectivity, linear thermal expansion, vapor pressure, electric resistivity, and the latent heats of fusion, vaporization and sublimation) of those solids melting above 1,000 F. (polymers, elements, alloys, cermets, ceramics, intermetallics and composites). Data were compiled and prepared by researchers at Armour Research Foundation, working under an Air Force contract. $90 for either set. Write: The Macmillan Co., 60 Fifth Ave., New York 11, for the bound edition; Pergamon Press Inc., 122 E. 55th St., New York 22, for the looseleaf set.

Proceedings of the Fifteenth Annual Power Sources Conference. A 162-page, hardbound transcript of 37 papers presented to the conference held at Atlantic City, N. J., on May 8-11, under the auspices of the U. S. Army Signal Research and Development Laboratory's Power Sources Div. Papers were presented in six sessions, covering: Primary Fuel Cell Batteries, Regenerative Fuel Cell Batteries, Secondary Batteries, Primary Batteries, Solar Energy Conversion, and Thermal Energy Conversion. Single copies, $10; additional copies, $5 each. Write: PSC Publications Committee, P. O. Box 891, Red Bank, N. J.

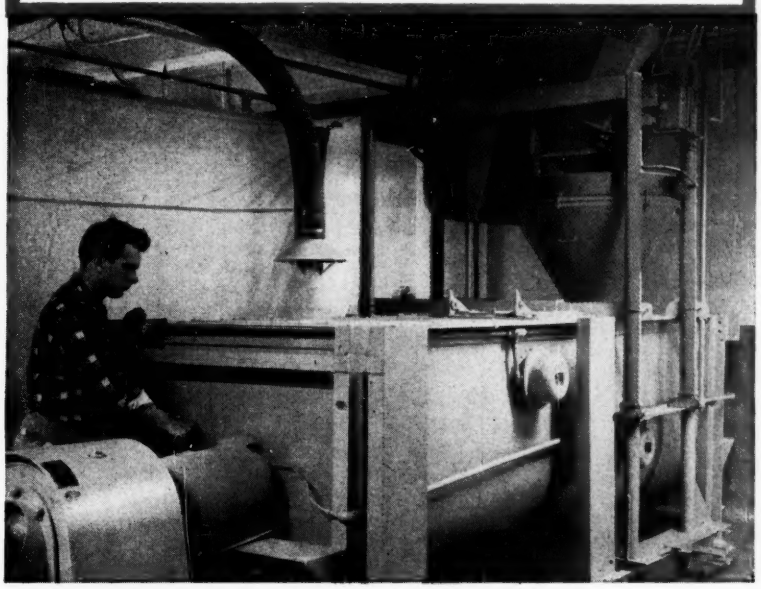
More New Books

Report Writers' Handbook. By C. E. Van Hagan. Prentice-Hall. 276 pages. $6.75.

Introduction to Feedback Systems. By L. D. Harris. Wiley. 362 pages. $10.50.

ENTOLETER® IMPACT MILLS

...true control assured for Colgate's "Ajax" line



- Improved Product Quality
- Elimination of Production Bottleneck
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Colgate-Palmolive has found that ENTOLETER IMPACT MILLS provide real benefits in processing "Ajax" household cleanser.

Engineered for simultaneous blending, grinding, and deagglomerating action, the IMPACT MILLS deliver a completely homogeneous, smooth-textured product.

With capacity per machine of 17½ tons/hr, these mills require less than 2.3 HP/ton/hr . . . Provide satisfactory wear life on highly abrasive materials.

Proven successful at Colgate's oldest and largest plant in Jersey City, ENTOLETER IMPACT MILLS have been installed in other "Ajax" producing plants throughout the U.S.

The Colgate-Palmolive Co. reports that "Blocking, packing, poor flow, and lack of product uniformity were ever present problems when the hammer-mill pulverizer was used. Installation of the ENTOLETER MILL gave TRUE CONTROL of the 'Ajax' line for the first time, including the automatic packaging step".

Investigate the advantages of Centrifugal Impact Mills TODAY! Write or phone for additional information and FREE LABORATORY TEST SERVICE.

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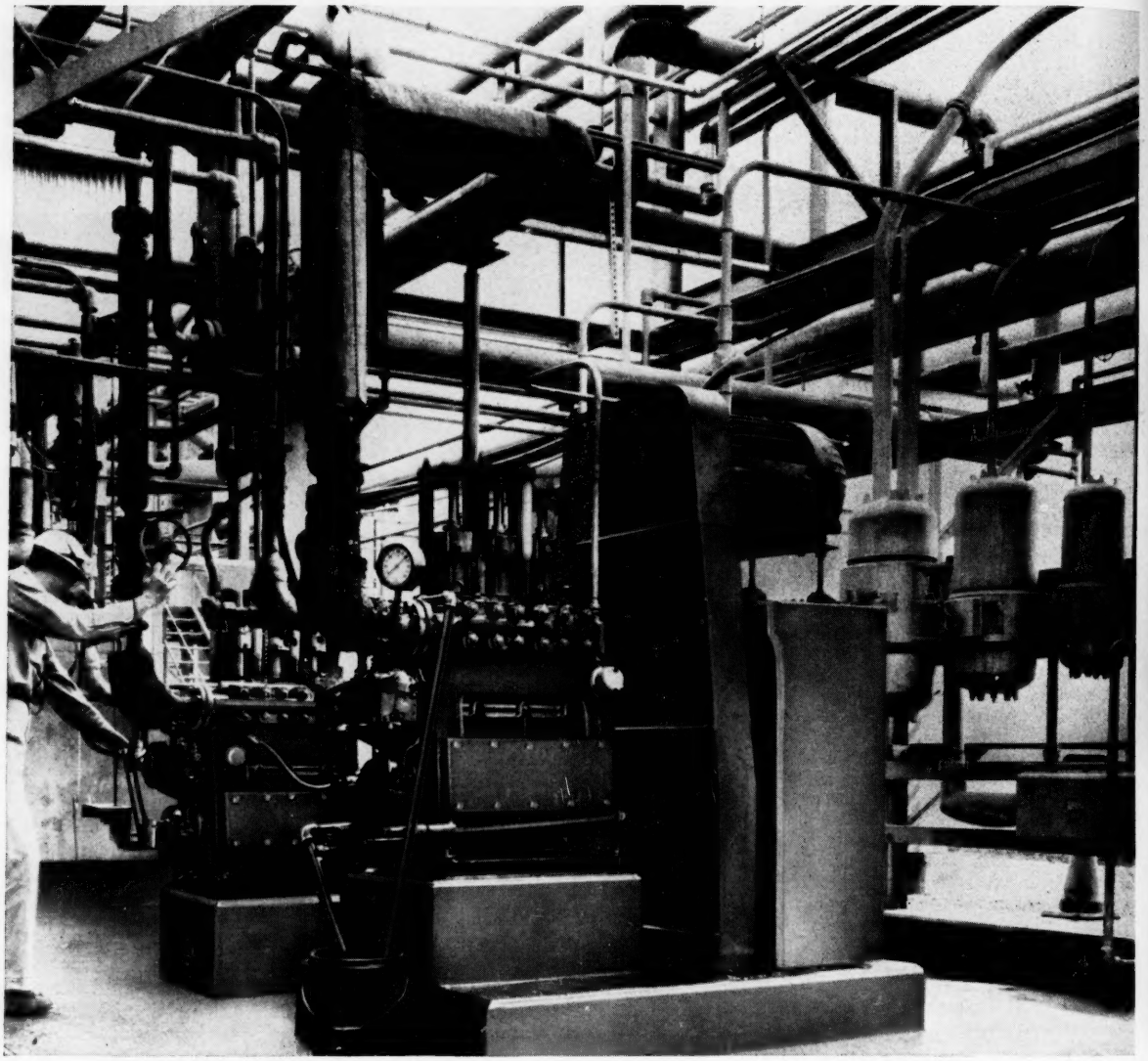


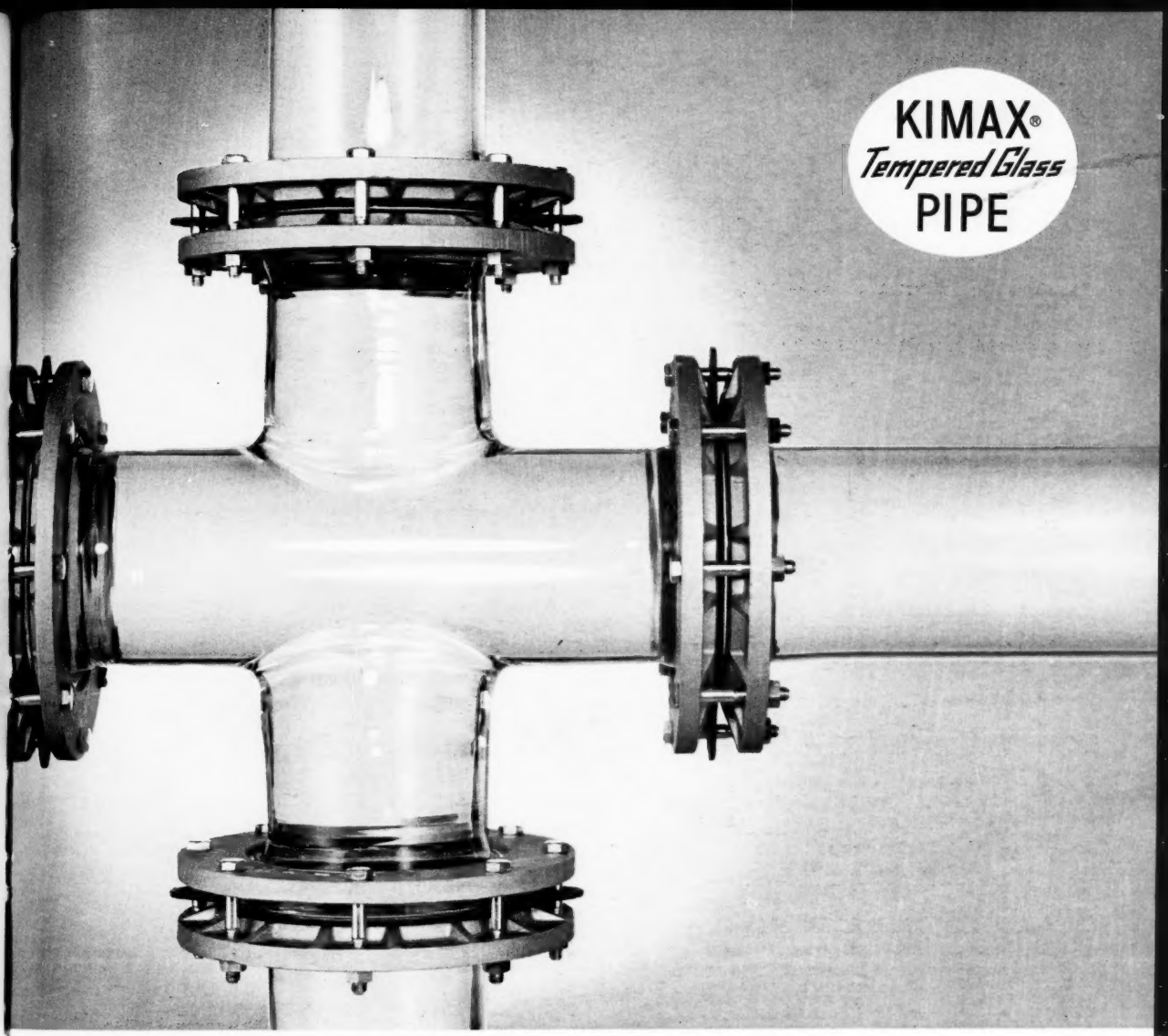
Aldrich pumps thrive on 24-hour liquid diet of anhydrous ammonia

At five years of age, these two Aldrich Triplex pumps are still at work for Southern Nitrogen Company. Service is continuous (168 hours a week), pump suction 185 psig, discharge 3000 psig, temperature 100 degrees F. No one said the job was going to be easy . . . and Aldrich pumps have once more proved their ability to handle the tough assignments. The only shutdowns required were for routine packing replacement, according to Paul Meyers, Superintendent.

Southern Nitrogen, at its Savannah, Georgia plant, produces a group of nitrogen chemicals. In handling liquid anhydrous ammonia, the Aldrich direct flow, reciprocating pumps have assisted in the production of urea. Pump plungers, valve seats and plates are of 440 C stainless steel for added insurance.

There are very few high pressure applications in the chemical industry that Aldrich pumps have not been called upon to handle. So don't hesitate to present your problem to our engineers—who have solved most pumping specials already. Corrosive, viscous, abrasive, or highly compressible fluids over a wide range of temperatures are now being handled by Aldrich pumps rated from 5 to 2500 hp., and up to 100,000 psi. For quick reference, consult our advertisement in Chemical Engineering Catalog, or write Aldrich Pump Company, 3 Gordon Street, Allentown, Pennsylvania. Remember . . .

THE TOUGH PUMPING PROBLEMS GO TO ALDRICH
SUBSIDIARY OF INGERSOLL-RAND



Your product stays pure... because KIMAX resists corrosion!

Do your present process pipe lines guarantee the purity of your product? If not, consider KIMAX Tempered Glass Pipe.

It resists corrosion and pitting — tiny particles cannot lodge. Smooth inner walls discourage build-up of scale and residue.

It has amazing resistance to impact damage and easily withstands sudden temperature differentials from steam to cool liquids.

KIMAX Glass Pipe is serenely indifferent to the savage attack of most acids and alkalis.

Since glass is inert, nothing is ever added to or taken away from your basic product.

Stoppages in the line can be spotted in seconds and remedied almost as quickly and easily.

And KIMAX Glass Pipe is economical . . . initial costs compare favorably with other pipe materials. Installation cost is usually less and maintenance cost is practically nil.

For more information about KIMAX Glass Pipe write Kimble Glass Company, a subsidiary of Owens-Illinois, Toledo 1, Ohio.

Distributed in the U. S. and Canada by Fischer & Porter Company, Warminster, Pa.

KIMAX TEMPERED GLASS PIPE
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GENERAL OFFICES • TOLEDO 1, OHIO

ONLY DRACCO CAN OFFER

sonic cleaning

(patented)

the most modern and efficient method for removing dust from glass-bag dust collectors

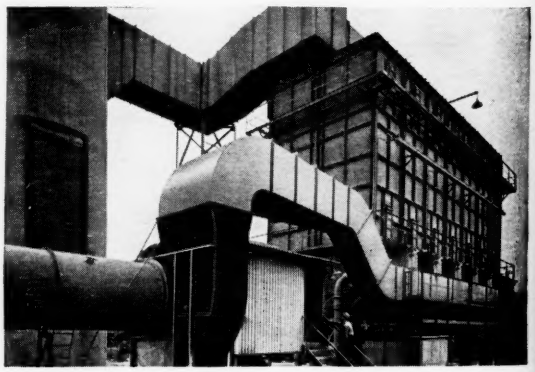
Dracco dust collectors now utilize one of industry's most exciting new techniques — *sonics* — to realize greatly improved glass filter bag cleaning action. This development is so significant that you should not specify or buy another dust control unit until you get the full story on sonic cleaning.

Sonic cleaning — patented and available exclusively from Dracco — provides three operating advantages: *low back pressure* through effective dust removal; *long bag life* since bags are not flexed, creased or shaken; *low maintenance* through elimination of moving parts within the collector.

Cleaning by low-frequency sound waves has been conclusively proved in full-scale field installations:
. . . on Glass-Bag Filters it is distinctly superior to reverse air cleaning alone.
. . . on conventional baghouses using cotton or synthetic bags it provides results second only to mechanical shaking. While mechanical shaking offers more vigorous bag agitation, sonic cleaning provides satisfactory cleaning with less bag wear and no internal moving parts.

Sonic cleaning is recommended for cement mill applications (kilns, grinding, classifying, materials handling), electric and open hearth steel furnaces, metallurgical furnaces, rock dryers, calciners, fusing furnaces, chemical processes and related applications.

You can get further information on Dracco sonic cleaning and expert consultation on your dust control requirements from: Dracco Division of Fuller Co., Harvard Avenue & East 116th Street, Cleveland 5, Ohio.

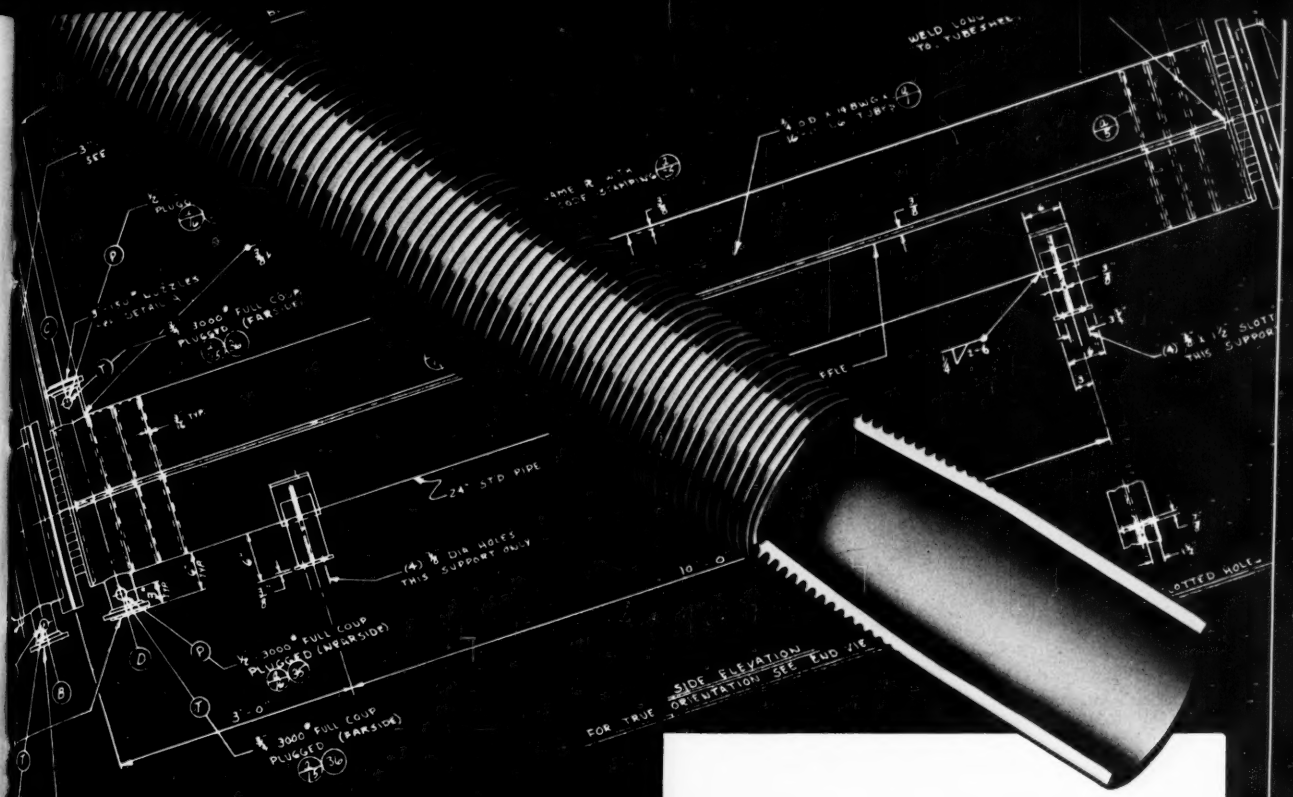


Proved in service — Dracco Glass-Bag Filter equipped with sonic generators cleans cement kiln gases. Sound waves dislodge collected dust without wear or fracture of cloth.

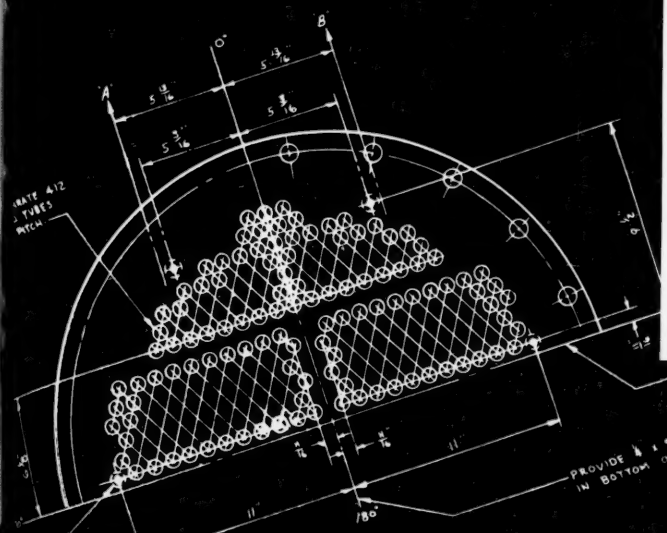
See Dracco at the 28th Exposition of Chemical Industries, New York Coliseum, Nov. 27-Dec. 1: Booth 495, Second Floor.

DRACCO *airstream* conveyors dust control equipment

FULLER COMPANY GENERAL



Wolverine TRUFIN® and STEEL ..go together—naturally!



In many applications—design and operating engineers are finding that they can cash in on money-saving benefits by specifying Wolverine Trufin Type S/T (19 fins per inch) in seamless steel.

Trufin—in steel—possesses all of the inherent advantages of integral finned tube. For example:

* **In new installations**—Trufin lets you design smaller exchangers without sacrificing capacity. You save on shells, headers, baffles, supports, etc.

* **When retubing**—Trufin's extended surface makes it possible to dramatically increase the capacity of existing exchangers. Trufin Type S/T can be substituted directly for bare tube.

* **Trufin has stamina**—Trufin, because of its integral fins, has the ability to stand up under rigorous operating conditions. Fins are part of the tube wall and are unaffected by temperature and pressure changes and vibrations.

Trufin is produced in many types, sizes, and fin spacings-and in steel, copper, copper alloys and aluminum.

WRITE TODAY FOR MORE INFORMATION.

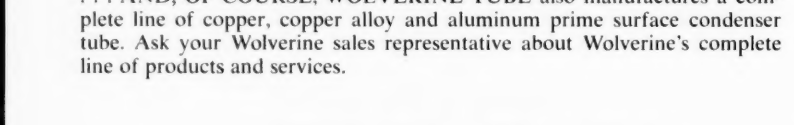
Look to Wolverine for the complete line of finned tube

Trufin Type S/T | Trufin Type W/H | Trufin Type S/T (Duplex) | Trufin Type L/C (Bimetal) | Trufin Type H/R | Trufin Type H/A | Trufin Type I/L

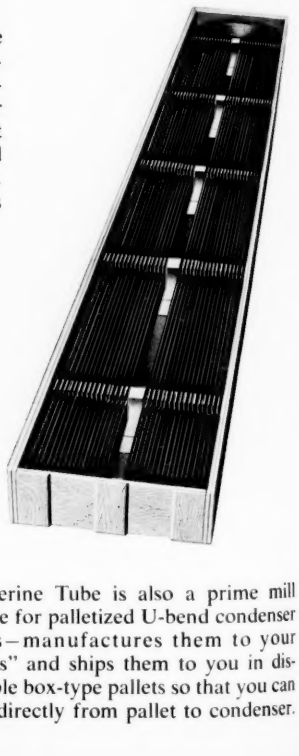
Only Wolverine Tube Division of Calumet & Hecla, Inc. can supply you with such a complete line of integrally finned tube – seven different types designed to bring increased efficiency to a wide variety of heat transfer applications. Each type is available in a complete range of sizes and alloys. Ask your Wolverine salesman for information about how these outstanding tubes can help you.

WOLVERINE ALSO OFFERS SPECIAL SERVICES AND SPECIAL PRODUCTS

Wolverine's Field Engineering Service is staffed with specialists trained in tubing selection, alloys, metallurgy, equipment design, etc. Also available for consultation are Wolverine's Heat Transfer Specialists who are located throughout the major processing areas. The services of all these men are yours –without obligation.



. . . AND, OF COURSE, WOLVERINE TUBE also manufactures a complete line of copper, copper alloy and aluminum prime surface condenser tube. Ask your Wolverine sales representative about Wolverine's complete line of products and services.



Wolverine Tube is also a prime mill source for palletized U-bend condenser tubes – manufactures them to your "specs" and ships them to you in disposable box-type pallets so that you can feed directly from pallet to condenser.

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from NATIONAL CARBON COMPANY

DIVISION OF UNION CARBIDE CORPORATION, 270 PARK AVENUE, NEW YORK 17, N. Y.
OFFICES: Birmingham, Chicago, Houston, Los Angeles, New York, Pittsburgh, San Francisco. In Canada: Union Carbide Canada Limited, Toronto

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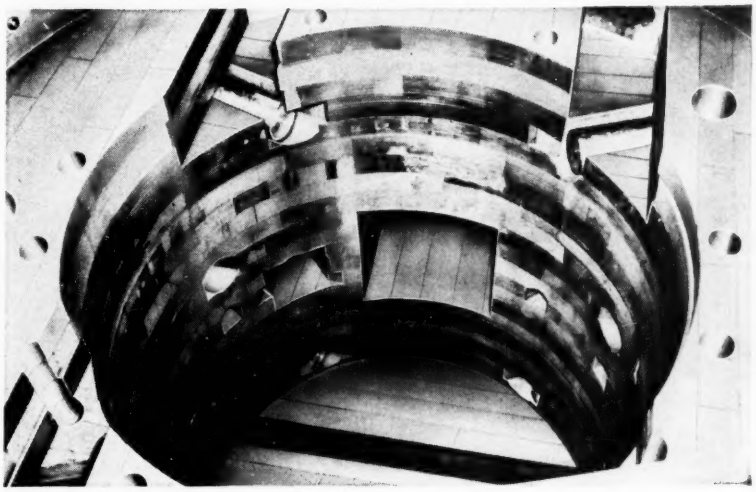
Through its combination of unsurpassed research, engineering, and production facilities for nuclear graphite, NATIONAL CARBON is fully equipped to meet the special needs of the industry. NATIONAL CARBON invites discussion of any potential application of graphite.

Building of Test Reactors Continues Under University Research Programs



This graphite reflector for a test reactor is similar to the type now being constructed for the Georgia Institute of Technology by O. G. Kelley & Company

More and more colleges and universities are expanding their research programs to include nuclear reactors. One of the latest additions at the university level is the nuclear facility now under construction on the grounds of the Georgia Institute of Technology in Atlanta, Georgia.

Nuclear graphite from NATIONAL CARBON is used in the reflector, which is similar to the type shown in the above illustration.

The Georgia Tech Research Reactor was designed to satisfy as many requirements in a broad research program in nuclear science as possible. Its breadth of utility not only embraces classroom practices and material testing, but also serves as a basic research instrument for advanced experimentation, including medical research.

The Georgia Tech reactor is very similar to the CP-5 Argonne Research Reactor and, in some respects, the MIT reactor. It will have an initial power rating of 1000 kw, with an eventual capacity of 5000 kw.

Since its pioneering use in the first reactor at Stagg Field, University of Chicago, "National" nuclear graphite has been increasingly employed in applications such as: moderator, reflector, thermal column, fuel element concepts, and control rods. Extremely resistant to thermal shock, and with no danger of melt-down, graphite is the logical solution to the higher-temperature reactors of the future.

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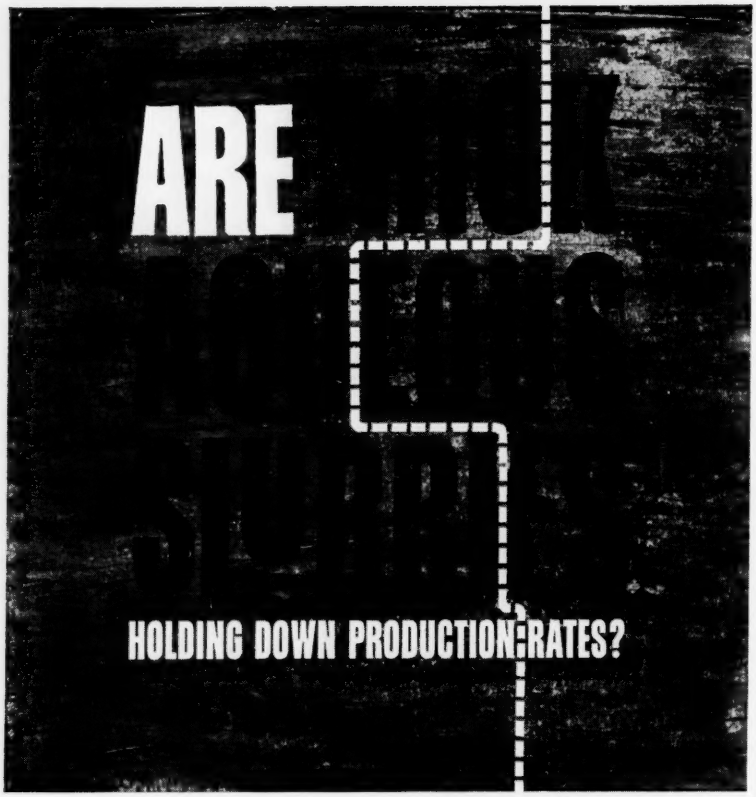

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PRO & CON . . .

Continued from page 7

Work—All energy transferred between the system and the surroundings during a particular period which is in no way connected with mass bulk flow and which arises as the result of a potential gradient other than temperature between the system and the surroundings.

With these definitions in mind, if one selects the gas as the system (example one), then work is done. With the selection of the piston and gas as the system, no work is done, since no energy other than heat is transferred from the system to the surroundings. (Had the pressure of the surroundings been specified to be any value less than 10 lb./sq. in. abs., then work would be performed on the surroundings.)

The term $\int PdV$ can occur as a quantity representing work; it can also result from a relationship between properties. If this term is used to represent work, P must be the pressure of the restraining boundary of the system. If one chooses a portion of the gas as the system, the pressure of the restraining boundary can be closely approximated by the pressure of the gas. However, if one arrives at $\int PdV$ from a relationship of properties, then P is the pressure of the system and not that at the restraining boundary. Only in the limit of a reversible process are the P terms equivalent. Is this not the P and P' distinction made in the first example?

It would be interesting to examine the definition of P that Dr. Cannon has proposed, with the amended condition that the piston shaft extend through a closed space, above the piston, that contains a gas with a volume comparable to that below the piston.

Two other points relative to this example: First, how fast can heat be transferred across the boundary? In reality, there must be a temperature fluctuation in the gas and piston. This in itself would be highly irreversible. Thus, this process cannot be isothermal but more nearly can approach adiabatic conditions. Second, the example also points out the lack of understanding of force and mass units.

In the second example, the term

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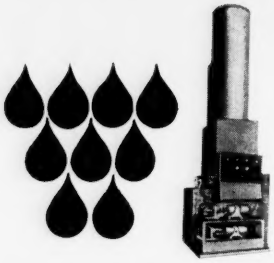

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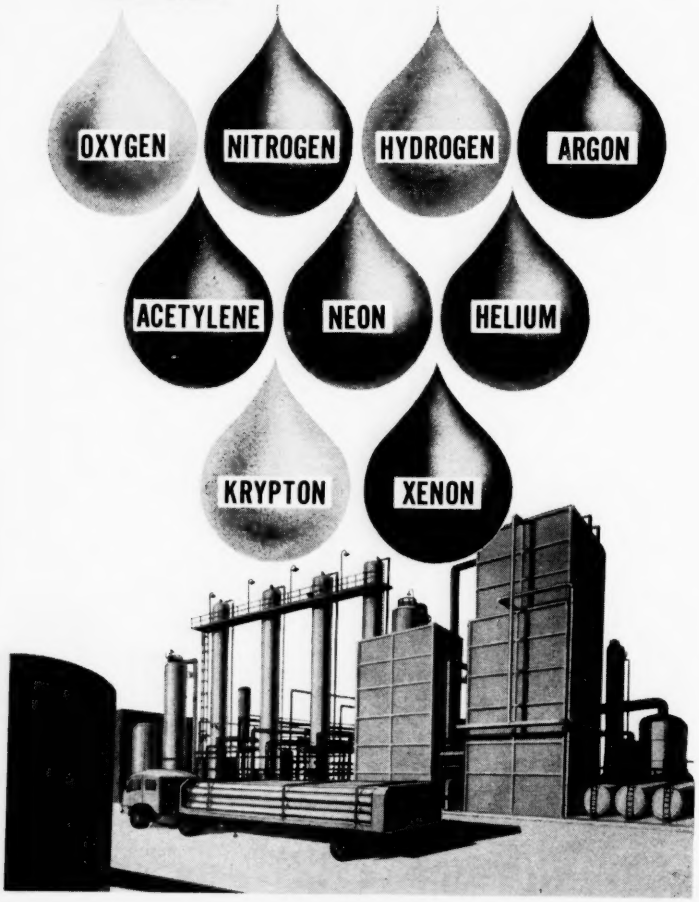


PRO & CON . . .

$\int PdV$ again is handled incorrectly. If a quantity of gas in the cylinder is taken as the system (Dr. Cannon's selection), then P is the pressure at the restraining boundary. In a reversible expansion, this value of P can be replaced by the pressure of the system. Under these conditions, work is performed. If the cylinder and gas are taken as the system, then work is not done on the surroundings. Hence, the same example can be analyzed by a different choice of system, and a conclusion is reached that "when a gas expands into an infinite vacuum, no work is done." Of course, the assumption that the gas expands reversibly is true only in the limit of an infinitesimal ΔP; thus the entire process is irreversible.

ANDREW COSGAREA, JR.
University of Oklahoma
Norman, Okla.

Dry vs. Wet Extinguishers

Sir:

As public relations counsel for Ansul Chemical Co., we were very much interested in your article (Aug. 7, p. 78) on liquefied bromotrifluoromethane, trademarked FE 1301 by Du Pont.

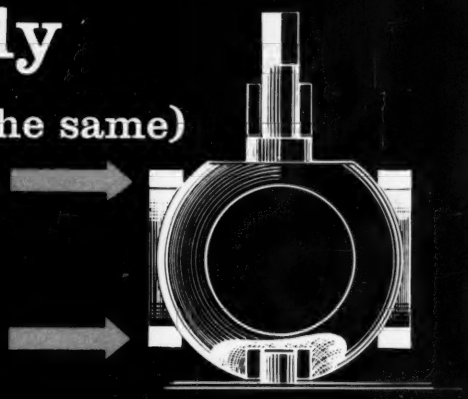
The article reports figures on the relative effectiveness of FE 1301 compared with other fire-extinguishing agents. These figures, which make FE 1301 look very good, are theoretically true when based on the agents alone. However, they do not hold true when the agents are applied from extinguishers.

Most sodium bicarbonate-base dry-chemical extinguishers of 2½-lb. capacity receive UL 4-B:C ratings, and one 2¾-lb.-capacity dry-chemical extinguisher receives UL 6-B:C rating. Yet your article goes on to say that "a conventional fire extinguisher containing 2¾-lb. of FE 1301 has received UL 4-B:C rating, might qualify for 6-B:C." This clearly shows that the extinguishing effectiveness of a sodium bicarbonate-base dry chemical is equal to or better than FE 1301 when applied from an extinguisher.

BARNEY FREEMAN
T. N. Palmer & Co.
New York, N. Y.

Look closely

(not all ball valves are the same)



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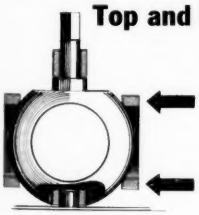
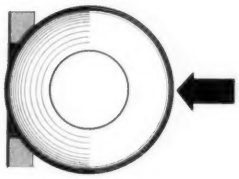
Top and Bottom Guided *FLO·BALL*



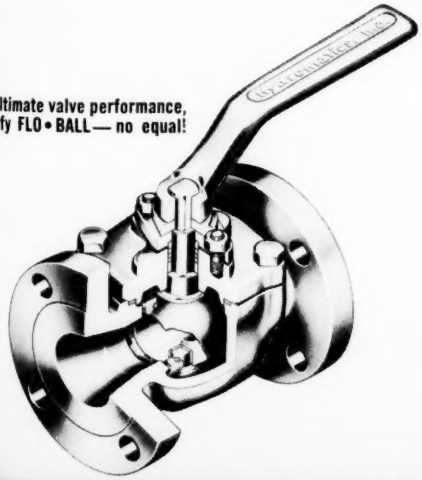
Unlike other ball valves, **FLO·BALL** seats do not serve as bearings. By putting the bearing loads where they belong — on frictionless Teflon bearings — the seat can then perform its basic sealing function. Result: longest seat life, lowest torque, in sizes through 36", pressures to 10,000 psi, temperatures from cryogenic (−423° F) to +500° F, for on-off and throttling.

Floating Ball Valves



Other makes of ball valves put the crushing burden of bearing loads right on the fixed seats. This results in seat distortion, hard turning and short life.

Fill in reverse side and mail today!



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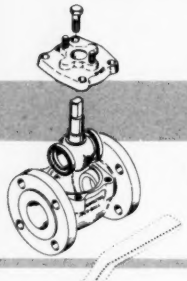

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1. TOP ENTRY All internal parts can be removed and re-installed without removing valve from line.	✓			✓		
2. TOP AND BOTTOM GUIDED BALL Provides truly double seal, extends seat life. Makes for easy operation.	✓					
3. DOUBLE SEATS Interchangeable and replaceable seats insure sealing in both directions; give double protection against leakage.	✓	✓	✓	✓	✓	✓
4. FLANGES INTEGRAL WITH BODY Rugged, one-piece body design gives greatest possible strength.	✓	✓		✓		
5. ONE PIECE BALL AND STEM No possibility of separation of ball from stem. Always perfect alignment with zero backlash. Foolproofed for assembly.	✓					
6. BLOCK AND BLEED Top and bottom guided ball and floating seats provide simultaneous up-stream and down-stream seal . . . a true block and bleed valve. Block and bleed type available on special order.	✓					

Specify the FLO • BALL for your application

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Pressures	Vacuum — 600 # — 3000 #	150 # — 300 # — 600 # (ASA Rating)
Materials	Carbon Steel, Stainless Steels, Semi-Steel, Brass, Alloy 20, Monel	
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44a—Floodlights

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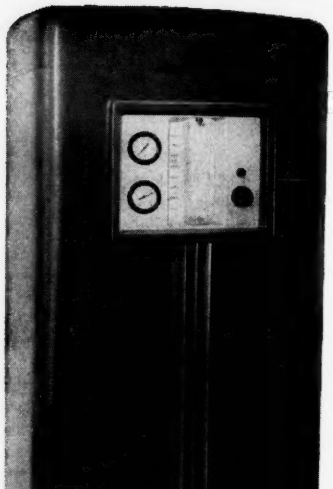
Solve your industrial water and waste problems -



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Wallace & Tiernan V-notch chlorinators provide the economical answer to water- and waste-treatment problems. Chlorine's bacteria- and slime-killing power keeps process and cooling waters slime-free. It destroys cyanide and phenolic wastes. It helps prevent organic fouling of demineralizers.

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- *If you have a water or waste treatment problem, W&T has the equipment and know-how to solve it. Write Dept. S-148.29.*

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

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Chemicals

Acid Gas.....30-page technical report 6.61, with graphs and diagrams, discusses an economical way to remove acid gas by the hot potassium carbonate process.
178A Solvay Process Div.

Activated Carbon.....A complete line of activated carbons for every purpose; design & prefabricate complete purification, separation & recovery systems. Bulletin J-119.
L205 *Barnebey-Cheney

Aluminum Chloride.....Technical data sheet TD-1 describes product and lists properties, analysis, applications plus shipping and handling information.
178B Pearsall Chemical Corp.

Antacid.....Aluminum hydroxide-magnesium carbonate co-dried gel characteristics discussed in booklet with text supplemented with tables and charts.
178C Reheis Co. Inc.

Brightener....Calcofluor White brightener for treating packages. Emits eye-catching brilliance. Additional information on this product is available on request.
16-17a *American Cyanamid Co.

Chemicals.....for a wide variety of applications. A booklet, "Harshaw Chemicals for Industry and Laboratory" is available on request for information.
185 *Harshaw Chemical Co.

Filter Aid.....Celite filtration assures the right grade for every degree of clarity. Full details on how Celite gives the fastest, most efficient filtration.
30 *Johns-Manville

Filter Medium.....Anthrafilt will give filter runs approximately twice as long as sand or quartz. Rates up to 200 mgd are obtainable with less clogging.
BR204 *Anthracite Equipment Corp.

* From advertisement, this issue

Fluids and Lubricants.....Characteristics and advantages of Ambiflo line of synthetic fluids and lubricants (polyalkylene glycol type materials) described in technical bulletin.
179A Dow Chemical Co.

Fluorosilicones....3 bulletins on fluorosilicone fluids, greases and compounds contain properties and performance charts and graphs, and suggested applications.
179B Dow Corning Corp.

Furfural.....for new product or new process development. Additional information plus physical data on Furfural is contained in Bulletin 203-A which is offered.
63 *The Quaker Oats Co.

Hydroxyacetic Acid.....Product information bulletin describes multifunctional chemical with uses in cleaning, chelation, dyeing, electroplating and as an intermediate.
179C E. I. du Pont de Nemours

Inert Gases.....Catalog on inert gas generators explains how to produce inert gases economically, lists specific uses and diagrams cost of finished product.
179D C. M. Kemp Mfg. Co.

Light Absorbers.....Cyasorb light absorbers cause vinyl to resist discoloration and cracking under ultra-violet rays. Further information on this product is offered.
16-17c *American Cyanamid Co.

Methocel Products.....are used as thickeners, film formers, binders, stabilizers, water retention agents and for thermal gelling. A Methocel Handbook is available.
158-159 *Dow Chemical Company

Methylamines.....64-page booklet contains review of all available technical data on the methylamines with discussions on shipping, handling, storage and safety.
179E Commercial Solvents Corp.

Monomer.....Data on triallyl cyanurate (TAC) should be helpful in research directed toward upgrading vinyl systems by increasing heat resistance & decreasing flow.
16-17d *American Cyanamid Co.

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COUNT ON THE NEW W&T SERIES 100 PUMP WHEN YOU NEED...

...ACCURATE METERING WITH SMOOTH CONTROL

Wallace & Tiernan's newest plunger pump delivers 3.2 gph vs 1200 psi to 50 gph vs 100 psi, repeatable within ± 1%. Easy adjustment over 10:1 range with the pump running.

...DOUBLE CAPACITY OR TWO-LIQUID METERING

A second liquid end doubles capacity or gives simultaneous feeding of two liquids. Stroke length for each end individually adjusted.

...DEPENDABLE, TROUBLE-FREE METERING

Unitized construction means the Series 100 Pump stays in perfect alignment. Wear and maintenance are held to a minimum. Corrosion-resistant wetted parts handle most chemicals. The Series 100 Pump, with motor, is compact. With two liquid ends it occupies less than 2 sq. ft.

For more information write Dept. L-8.29

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

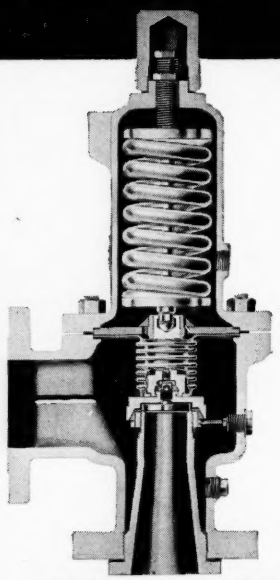
value...

the reason FARRIS OUTSELLS all others

Farris Process Safety-Relief valves have unique design features which provide product serviceability and dependability unmatched by *any* competitive valve. True value is "built into" Farris valves.

- **2½ to 1 ratio—guide length to guide diameter—prevents galling and hanging up.**
- **High thermal expansion of sleeve guide and low thermal expansion of hardened stem retainer stops binding at high temperatures.**
- **Hardened stainless steel optically lapped disc . . . self aligning for maximum tightness.**
- **Elimination of effects of back pressure by "BALAN-SEAL" bellows permits use of smaller discharge piping . . . Saves up to 15 times the cost of the valves . . . isolates internal working parts from lading fluid.**
- **Industry's most complete line. Available in cast iron, steel and special materials. Sizes ½" to 8". Pressures to 10,000 psig. Temperatures to 900°F. Enclosed or exposed springs. Plain, open lever or packed lever construction.**

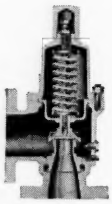
All Farris Nozzle Valves Conform To ASME Power Boiler Code, Section 1, and The ASME Unfired Pressure Vessel Code, Section 8.



Series 2600 . . Balan-Seal bellows. 150 to 6000 psig. Also without bellows.

Series 2740 & 2741 . . . simple, rugged cast steel design. Pressures to 5000 psig @ 750°F.

Series 2745 . . . Durable, compact, high pressure nozzle valve. Internal parts 316 stainless steel. Pressures to 10,000 psig.



Series 2950 . . . Cast iron valve similar to Series 2600. Max. pressure 250 psig. @ 450°F, 400 psig. @ 150°F.

Write for **FREE** Catalog **FE-118**

GET FULL VALUE: Replace With Farris... Complete Interchangeability With Standardized Face To Face Dimensions.

ENGINEERING CORP.

501 COMMERCIAL AVENUE

PALISADES PARK, NEW JERSEY

AFFILIATES: Farris Combustion Controls Corp. • Farris Flexible Valve Corp. • Farris Universal Machine Corp. Farris Industries Canada Ltd. • Farris Engineering Ltd., London, England

LITERATURE . . .

Polybutene.....Characteristics, and present and potential uses of this versatile petrochemical product are comprehensively reviewed in a 31 page technical brochure.
180A California Chemical Co.

Polyethylene....Physical properties and principal industrial applications of line of low molecular weight poyl-ethylene resins listed in bulletin F-110.
180B Eastman Chem. Prod. Inc.

Processing Chemicals.....16-page catalog JWL-100 lists products and furnishes a brief description of each. End uses for principal applications are also described.
180C Nopco Chemical Co.

Reinforced Plastics.....40-page manual "Fiberglas-Reinforced Plastics" was designed to provide an up-to-date compilation of data on FRP to facilitate decisions.
180D Owens-Corning Corp.

Surfactants.....Technical data sheet describes low foam, alkali stable surfactants of high wetting and suspending power used in textile processing.
180E Beacon Chem. Ind. Inc.

Vinyl Emulsions.....24-page brochure "Airco Vinyl Emulsions for Exterior and Interior Latex Paints" features suggested paint formulations and gives physical properties.
180F Air Reduction Co.

Construction Materials

Acid-Proof Cements.....Guide to the selection of the proper cement for corrosion proof installations lists more than 75 corrodent solutions and rates the various cements.
180G Acid-Proof Cement Mfg. Assn.

Aluminum Conduit....solves most corrosion problems in and around chemical plants. It's light weight, nonmagnetic and non-sparking. Additional information available.
71 *Rome Cable Div., Alcoa

Block Insulation.....PV Supertemp block insulation is highly efficient and practically dustless. It is easily cut to fit irregular areas with no special tools.
26 *Eagle-Picher Company

Construction Material.....Fluoroflex is a specially processed Teflon construction material used for pipes, bellow & expansion joints, transfer hose, etc. Inform.
133 *Resistoflex Corp.

Gaskets.....28-page booklet PK-152A is divided into six basic sections each describing a basic metallic gasket with photographs and cross-sections, augmented with descriptive copy.
180H Johns-Manville

Insulation.....Foamglas insulation is completely waterproof and is incombustible. Solves insulation problems above or below ground, indoors or outdoors. Catalog.
141 *Pittsburgh Corning Corp.

Mechanical Packings.....A full line of mechanical packings such as high pressure asbestos, rotary pump packings, valve packings and many others.
162 *Belmont Packing & Rubber Co.

* From advertisement, this issue

IDEAS in chemistry from Norton

Thermal stability . . . unusual purity. This is what the research chemist looks for in refractory materials. Norton Company offers him both.

Hydrogen for a variety of applications is available today from high temperature reactors lined with fused aluminum oxide refractory material. The requirement here is to contain the reaction . . . *containment without contamination.* Norton material meets the need. One important use of this hydrogen . . . which can be made anywhere . . . is in ammonia-base fertilizers for sub-marginal land.

Maleic and phthalic anhydrides, and ethylene oxide, are products of reactions which offer a similar challenge. The catalyst carriers for these reactions must have heat resistivity, uniform size and porosity, and a purity not commonly found in ceramic materials. Norton pioneered their development, and has a fund of knowledge for anyone interested in catalysis.

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NORTON
REFRACTORIES
Crystallizing ideas into products

New ECLIPSE HIGH-TEMPERATURE HEATER

...for hot oil, Dowtherm*, Aroclor**

Under wraps—the revolutionary **Eclipse High-Temperature Heater.** Available in 10 sizes, with output capacities to 6,000,000 Btu/hr. Gas- and/or oil-fired. Fully automatic. "Packaged" design.

See it unveiled Nov. 27 at the Chem. Show, Booth No. 973

Visitors to this year's Chem. Show will see the new **Eclipse High-Temperature Heater** for liquid phase process heating systems.

Here's a brief preview of its advanced design features:

- Uses low-cost heat transfer media — designed for residual petroleum oils — also uses Dowtherm, Aroclor, and others.
- Closed liquid phase system — maintains high temperatures *without pressure.*
- Horizontal design — requires minimum headroom (as little as 57") — *side firing* cuts floor space requirements 20% over conventional end-fired units.
- Exclusive "directed" circulation — special interior design promotes rapid circulation—prevents carbon separation or "baking" on.

Plan to see this new **High-Temperature Heater** at Booth No. 973 some time during the Chem. Show. An Eclipse representative will be on duty to discuss with you the many advantages of these and other Eclipse units. If you can't be at the Chem. Show this year, see this new Eclipse heater unveiled in the December 11 issue of *Chemical Engineering* magazine. Look for our advertisement.

*Reg. T.M. Dow Chemical Co. **Reg. T.M. Monsanto Chemical Co.

Eclipse®

ECLIPSE BOILER DIVISION
Manufacturers Rd. & Compress St.
Chattanooga 5, Tennessee

LITERATURE . . .

Nickel Alloys.....Inconel alloy 600 & Monel alloy 400 have excellent resistance to corrosion by hydrogen chloride & chlorine. Technical Bulletins T-5 & T-7 are offered.
75 *International Nickel Co.

Nuclear Graphite.....No other material has so many useful nuclear properties. It is an excellent structural material, resists corrosion & is easily fabricated.
169 *The National Carbon Co.

Pipe Insulation.....Snap-On is the only one-piece pipe insulation available in sizes from copper tubing to 36" IPS. More complete information is available.
49 *Gustin-Bacon Mfg. Co.

Pipe Lining.....Fluorogreen E-900 is a corrosion-proof, noncontaminating lining for pipe, tees and ells. Further information is contained in Data Sheet E-900 which is offered.
161 *John L. Dore Co.

Plate Steels.....The Lukens Application Research team would welcome the opportunity to work with your engineers on problems involving plate steels. Inform.
38-39 *Lukens Steel Co.

Refractory, Silicon Carbide.....Crystolon "63" has high thermal conductivity, excellent heat shock & wear resistance, & good resistance to most corrosive liquids.
181 *Norton Co., Refractories Div.

Rubber Linings.....for tanks, pipe & proces equipment. Permanent protection against corrosion & contamination. Permanent rubber-to-metal bond. Cat. No. 7115.
123 *Raybestos-Manhattan, Inc.

Steel.....Type 2 aluminized steel is ideal for drying and processing ovens because it is two metals in one with a unique combination of properties.
171 *Armco Steel Corp.

Steel.....T-1 steel reduces weight and has four times the resistance of carbon steel to atmospheric corrosion. A booklet, "USS T-1 Steel" is available on request.
24-25 *U. S. Steel Corp.

Urethane Coatings.....Brochure discusses superiority in resistance against chemicals, corrosion, abrasion, weather and wear of urethane compared with other types of coatings.
182A Better Finishes & Coatings

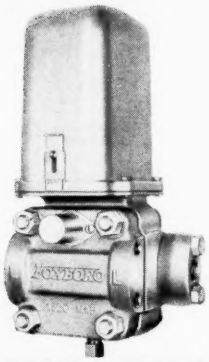
Urethane Finishes.....Bulletin 59-C15 discusses polyurethanes that, because of their propensity to react with many familiar vehicles, are of interest to the coatings industry.
182B Mobay Chemical Co.

Electrical & Mechanical

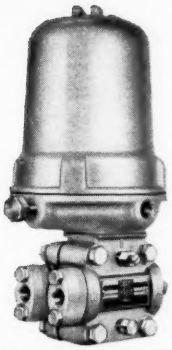
Cable.....MI cable is ideally suited for all types of trouble areas. The many unique characteristics of this versatile cable construction in the new MI catalog.
189 *General Cable Corp.

Code Cover.....A handy pocket size brochure is available giving complete details on a new patented Outlet Protector Cover with a tablet of dye that penetrates wet plaster.
182C *Appleton Electric Co.

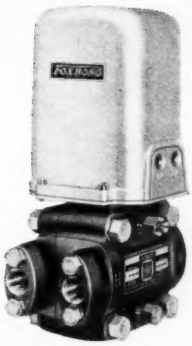
* From advertisement, this issue



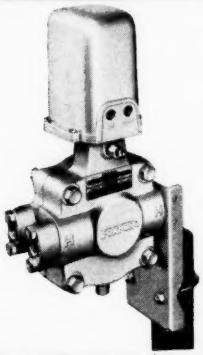
T13AA — for absolute pressure of dryers, columns, evaporators.



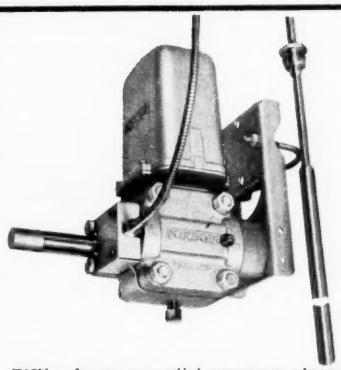
T613 — for long distance measurement of flow, level, pressure drop. All electronic transmission.



T13A — for metering practically all process flows, densities, liquid level.

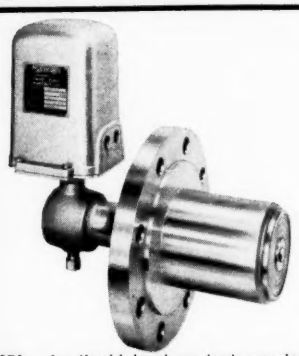


T15A — for small pressure drop across filters, heaters, orifices; for small liquid level heights, density measurement.

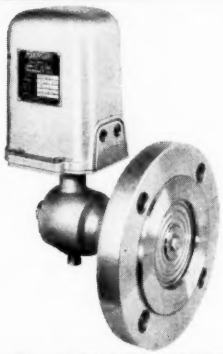


T13V — for vapor partial pressures, steam stripping or column control.

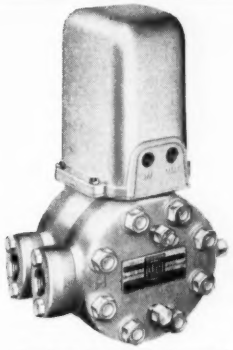
T13A — for metering additives, inhibitors, reactants, product gas or liquid — .003 to 10 gpm.



T13FA — for liquid level on tank nozzles without pocketing of process fluids: mounts flush with tank interior.



T13FA — for liquid level measurement: mounts direct on nozzle or tank flange.



T13HA — for flow, level, interfaces at pressures up to 6000 psi.

these Foxboro d/p Cell* Transmitters are related ...in design – in accuracy – in savings for you

These are the transmitters every company needs, to know and control its processes. To keep track of purchases, production and sale of fluids. To maintain close control of costs, quality, and safety.

And since each uses the same basic Foxboro d/p Cell, you get all the advantages of standardization. Universal calibration techniques—simplified training of personnel—reduced stocks of component parts. Plus the highest sustained accuracy of measurement and transmission under the most punishing operating conditions.

Pneumatic or electronic systems, new plant or modernization, why not standardize on industry's standard — the Foxboro d/p Cell Transmitter. Write today for descriptive literature. The Foxboro Company, 3611 Neponset Ave., Foxboro, Mass.

Reg. U. S. Pat. Off.

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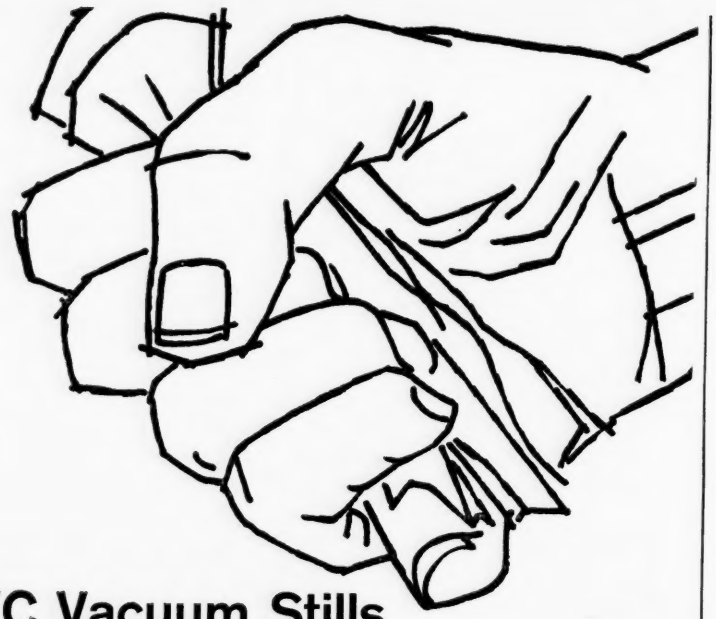


CVC Vacuum Stills Squeeze the extra profits out of waste

Put the squeeze on the residue from your commercial separation process—and chances are you'll recover extra profits in the form of saleable byproducts.

Many industries are doing it right now with CVC Molecular Vacuum Stills—at a utility cost of *less than 1/10¢ a pound!* And CVC Stills handle today's widest range of organic and silicone products (from 250 to 4000 molecular weight).

It's CVC high vacuum that does it! Keeps temperatures down—reduces heat in-put costs and thermal hazards—increases yield by cutting down decomposition.

CVC Stills run virtually unattended to save you man-hours. There's a complete line available, giving you through-puts from 2 to 4000 pounds per hour. Just ask your CVC representative.

WRITE for Bulletin 3-1 on CVC Molecular Vacuum Stills. Ask us about the possibility of additional profits from your commercial separation process and about test runs of your samples.

Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

A SUBSIDIARY OF CONSOLIDATED ELECTRODYNAMICS/BELL & HOWELL

LITERATURE . . .

Flexible Couplings.....Bulletin gives selection information and describes couplings able to accommodate every combination of misalignment at all rated speeds with no power drop.
184A Lovell Mfg. Co.

Floodlights.....for any explosion-prone area. A catalog is offered giving descriptions of floodlights for explosion-proof illumination. Catalog Number 320.
44a *Crouse-Hinds

Motor Testing.....Technique for measuring and recording the torque-speed and current-speed characteristics of electric motors is discussed in brochure AN-106.
184B F. L. Moseley Co.

Motors.....Type JP motors are built with rugged, corrosion-resistant cast iron frames. Both ends have running shaft seals to keep heavy-duty bearings clean.
160 *Wagner Electric Corp.

Motors.....Life-Line AC motors offer 15% more hp at no increase in price. A complete line of motors, gearmotors, speed reducers & adjustable speed drives.
36-37 *Westinghouse Electric Corp.

Pneumatics.....Catalog describes company's line of air-powered equipment, gives applications of materials dispensing equipment and includes selection guide.
184C Lincoln Engineering Co.

Power Supplies.....44-page catalog covers complete line of both standard and custom engineered power supplies, ranging from 50 watts to 5,000 kilowatts.
184D American Rectifier Corp.

Rotor Motors.....Ranging in size from 1-30 hp., motor designed to meet requirements of any wound rotor application including elevators, hoists, etc., is described in bulletin.
184E Louis Allis Co.

Unilets.....New CES-CESD type receptacle Unilet & matching plug gives outstanding performance for all industrial equipment. Bull. CES-660 is available on request.
1 *Appleton Electric Company

V-Belt Drives.....Handbook explains advantages of narrower and more powerful belt and sheaves plus explanation, charts and nomographs useful in designing special drives.
184F Dodge Mfg. Corp.

Handling & Packaging

Feeders.....Rotary airlock feeders for use in handling problems of dust control and for pneumatic conveying. Bulletin P58 is available upon request.
BL207 *Prater Pulverizer Company

Lift Truck.....Compact fork lift truck with capacity of 2000 lbs. and turning radius of 59 in. described in bulletin #1405 that lists structural and operational features.
184G Otis Elevator Co.

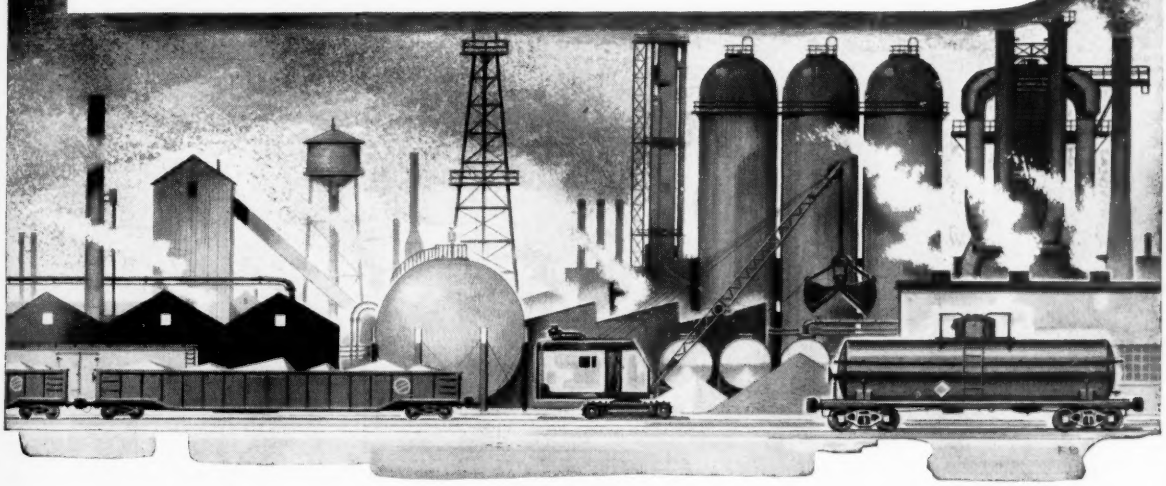
Pressurized Transports.....Can be fabricated of any material including T-1 steel, or various other steels. Complete specifications available.
4 *Pressed Steel Tank Company

* From advertisement, this issue

Is Your Industry Listed Here?

HARSHAW Manufactures Products for these and other industries

Abrasives • Aeronautical
Atomic Energy • Automotive
Brick and Tile • Ceramic
Cement and Concrete
Chemical • Cosmetic
Disinfectants
Electrical Manufacturing
Electronic
Electroplating • Enamel
Engraving and Electrotyping
Explosive • Fat and Oil
Feed Stuff, Mineral Feed
Fertilizer • Food
Foundry • Glass
Insecticide and Fungicide
Laundry • Leather
Lithographing
Linoleum and Floor Covering
Lubricant • Match
Metallurgical • Metal Working
Oil Cloth • Optical
Paint, Varnish and Lacquer
Paper • Petroleum
Pharmaceutical • Photographic
Porcelain Enamel • Plastics
Pottery • Printing Ink
Pyrotechnic • Refractories
Rubber • Soaps
Steel • Textile
Welding Electrodes • Wall Paper



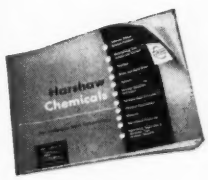
TO BE SPECIFIC: HARSHAW PRODUCTS FOR THE CERAMIC INDUSTRY

- **BODY STAINS, GLAZE STAINS, UNDERGLAZE COLORS**—Used in sanitary ware, tile, dinnerware, artware, and colored brick.
- **HYDROFLUORIC ACID, AMMONIUM BIFLUORIDE**—For frosting, etching and polishing glass.
- **PORCELAIN ENAMEL OXIDES**—Used in appliances, signs, steel sanitary ware, light fixtures.
- **GLASS ENAMELS**—For decorating beverage bottles, tumblers, and for glass wall panels.
- **CADMIUM SULPHIDE ORANGE**—Used in manufacturing colored glass.
- **VARIOUS METALLIC SALTS AND OXIDES SUCH AS:**

Antimony Oxide • Cadmium Acetate • Cadmium Nitrate • Cadmium Oxide • Cadmium Sulfide
Cobalt Carbonate • Cobalt Nitrate • Cobalt Sulfate • Copper Oxide Black • Manganese Hydrate
Nickel Carbonate • Nickel Nitrate • Nickel Oxide • Tin Oxide • Zinc Acetate • Zirconium Oxide

IN ADDITION: More than 50 miscellaneous batch raw materials.

We will be happy to provide information on any of the material listed above.



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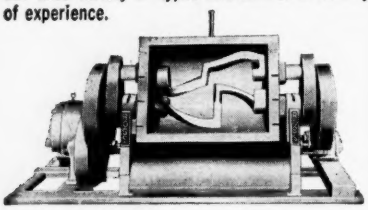
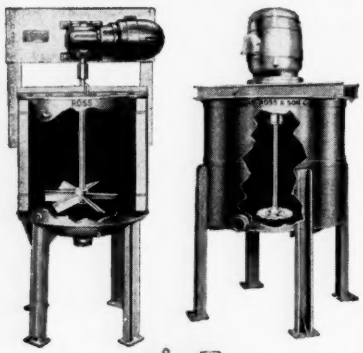
HARSHAW

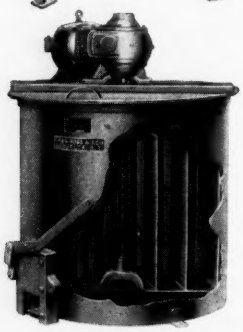
PROFIT MARGINS INCREASE...

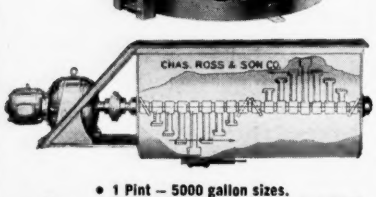
WHEN THE BEST MIXER IS USED FOR EACH APPLICATION

There is only one Mixer that is the most efficient for each different mixing requirement — let us recommend the best Mixer for your use based on our wide variety of types and almost a century of experience.









- 1 Pint — 5000 gallon sizes.
- Standard designs, or with any modifications required.
- Also Three Roller Mills, Dry Grinding Mills, and other types of Mixing, Grinding and Dispersing Equipment.

CHAS. ROSS & SON CO., INC.

Leading mfgrs. of *wet or dry grinding Mills, Kneaders and Mixers of all types — since 1869.*

150 Classon Ave., Brooklyn 5, N. Y.

LITERATURE . . .

Screw Conveyor Components.....A single component or complete systems—for standard or special requirements. Details are available on the complete line to match your need.
6 *Link-Belt Company

Heating & Cooling

Burner Units.....These gas firing burner units can be supplied with a medium pressure gas pilot for electric ignition. Literature & technical & engineering data offered.
73 *National Airoil Burner Co.

Cooling Equipment....Kathabar equipment eliminates freeze-ups, fluctuating efficiency, defrosting shutdowns & duplicate sets of coils. Facts are offered.
190 *Surface Combustion

Fuel Cells.....List of English language abstracts of German language fuel cell patent documents gives short description of patent and specifies number of drawings.
186A Metachem Laboratories

Gas Heating....Bulletin 320.1 describes application of electric heat in direct contact heating of gases to 1800°F. and contains chart for determining KW rating needed.
186B Hynes Electric Heating Co.

Heat Control.....Equipment such as temperature-pressure regulators, float thermostatic steam traps, thermo-dynamic steam traps & pipeline strainers for heat control.
80 *Sacro Company, Inc.

Heat Exchanger.....Aero Heat Exchanger is a self-contained fluid cooling system. It gives most accurate temperature control. Bul. No. 132 for complete information.
B193 *Niagara Blower Co.

Heat Exchangers.....Karbate impervious heat exchange equipment offers complete corrosion resistance, high thermal conductivity & immunity to thermal shock. Cat. Sec. S-6800.
57 *National Carbon Co.

Heat Exchangers, Pyrex.....Shell & tube, jacketed, cascade & candle-type heat exchangers are made. Design Manual for Pyrex brand modular shell & tube units offered.
125 *Corning Glass Works

High-Temperature Heater.....This new high-temperature heater uses low-cost heat transfer media. Features closed liquid phase system and horizontal design.
182 *Eclipse Mfg. Co.

Vaporizers.....offer unusually sensitive heat control by eliminating flash-down to achieve precise final temperatures. Feature fewer control devices.
79 *Foster Wheeler Corp.

Instruments & Controls

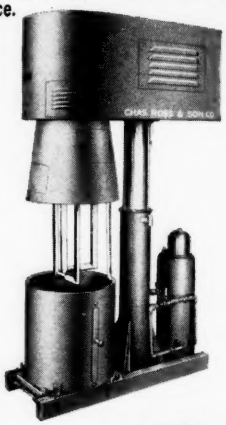
Bimetal Thermometers.....Catalog describes thermometers that cover industrial and laboratory uses plus alarm and control systems, maximum-minimum indication etc.
186C Weston Instruments Div.

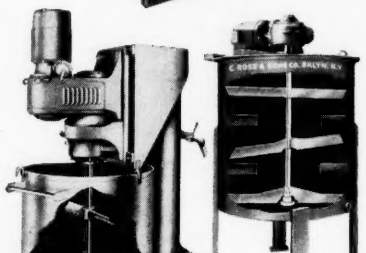
* From advertisement, this issue

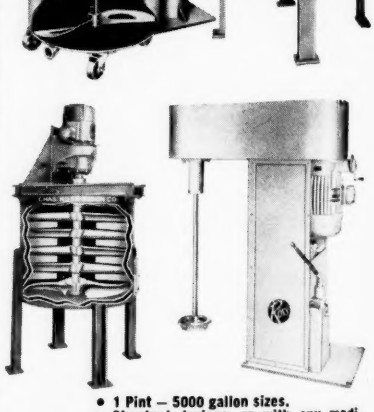
PRODUCTION COSTS DECREASE...

WHEN THE BEST MIXER IS USED FOR EACH APPLICATION

There is only one Mixer that is the most efficient for each different mixing requirement — let us recommend the best Mixer for your use based on our wide variety of types and almost a century of experience.







- 1 Pint — 5000 gallon sizes.
- Standard designs, or with any modifications required.
- Also Three Roller Mills, Dry Grinding Mills, and other types of Mixing, Grinding and Dispersing Equipment.

CHAS. ROSS & SON CO., INC.

Leading mfgrs. of *wet or dry grinding Mills, Kneaders and Mixers of all types — since 1869.*

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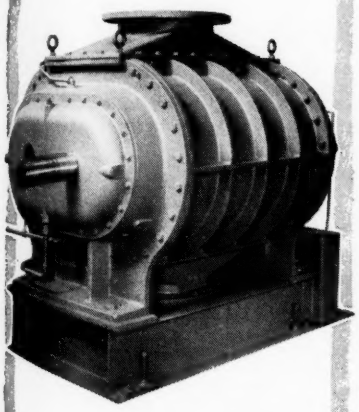


WHERE FAILURE COULD BE COSTLY ...SPECIFY SUTORBILT BLOWERS

In chemical plants and other critical installations, you can count on Sutorbilt rotary positive-pressure blowers for double dependability:

- Simple, rugged precision construction means long, reliable service. Rotors, gears and bearings are the only moving parts.
- Long-lasting, lip type seals, and non-lubricated compression chamber prevents air contamination.

There is positive, constant pressure. The two counter-rotating figure-eight Sutorbilt impellers produce a metered air supply.

Sutorbilt blowers and pumps deliver air and gas in capacities up to 23,000 cfm at pressures up to 12 pounds.

Write for detailed specifications on the versatile Sutorbilt Blowers, Dept. A.

Sales representatives in principal cities

4472
S-39

SUTORBILT CORPORATION
IS WELL BUILT

2966 EAST VICTORIA ST. • COMPTON, CALIF.
Subsidiary of Fuller Company • Catasauqua, Pa.

LITERATURE . . .

Chlorinator.....V-notch chlorinators provide the economical answer to water- and waste-treatment problems. More information is available on request.
178 *Wallace & Tiernan Inc.

Control Systems.....Provide maximum automation for data acquisition, transmission, recording and control of process variables. Technical Bulletin 10 available on request.
61 *Robertshaw-Fulton Controls Co.

Digital Control System.....Dynapar digital control is a highly accurate digital logic system. It can count, measure, totalize, indicate and time. Information.
93 *The Louis Allis Co.

Instruments.....Condensed 48-page catalog G-la describes company's instruments and systems for measuring, recording and controlling industrial processes.
187A Minneapolis-Honeywell

Liquid Level Controls.....Floatless Electrode type are unaffected by acids or caustics. Standard 2 & 3 pole units listed by U/L. Complete specifications in 32-pg. Catalog.
TL207 *Charles F. Warrick Co.

pH Electrodes.....are designed to meet the needs of industrial applications & built for use with all new Model J pH Analyzer. Details are found in Data File 14-48-16.
R205 *Beckman Instruments, Inc.

Regulators.....8-page bulletin on pressure reducing regulators discusses balance, pilot operated and direct acting valves and gives operation details for each type.
187B Strong

Rotameters.....How measurement and control of flow rates in pipes as high as 48 in. can be done economically is described in bulletin prepared for engineers and designers.
187C Brooks Instrument Co. Inc.

Telemetering System.....The Dynacode system is a new high-speed remote monitoring system based on Varec pulse code performance. Details in Bulletin 301.
139 *Dynel, Inc.

Temperature Regulators.....How to select and apply temperature regulators for stable and accurate control of process, storage and instantaneous heaters etc. described in brochure.
187D Spence Engineering Co. Inc.

Transmitters.....Descriptive literature is available for details on d/p Cell transmitters in both pneumatic or electronic models for your system.
183 *Foxboro Company

Pipes, Fittings & Valves

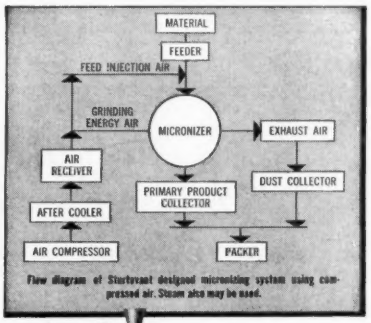
Ball Valve.....Flo-Ball offers top entry, in-line maintenance, top & bottom guided ball, double seats, flanges integral with body & other features. Lit.
173-174 *Hydromatics, Inc.

Ball Valves.....Double-Seal ball valves are available in a wide variety of materials and sizes for many applications. Literature is offered.
111 *Jamesbury Corp.

* From advertisement, this issue

Need ½ to 44 Microns?

Sturtevant Micronizers* Make 325 Mesh Obsolete



Flow diagram of Sturtevant designed micronizing system using compressed air. Steam also may be used.

One Operation Reduces, Classifies

Sturtevant Micronizers grind and classify in one operation in a single chamber—provide fines in range from ½ to 44 microns to meet today's increased product fineness needs. Can handle heat-sensitive materials.

Production Model (15 in. chamber)

No Attritional Heat

Particles in high speed rotation, propelled by compressed air entering shallow chamber at angles to periphery, grind each other by violent impact. Design gives instant accessibility, easy cleaning. No moving parts.

Classifying is Simultaneous

Centrifugal force keeps oversize material in grinding zone, cyclone action in central section of chamber classifies and collects fines for bagging. Rate of feed and pressure control particle size.

Eight Models Available

Grinding chambers range from 2 in. diameter laboratory size (½ to 1 lb. per hr. capacity) to large 36 in. diameter production size (500 to 4000 lbs. per hr. capacity). For full description, request Bulletin No. 091.

Engineered for Special Needs

A 30 in. Sturtevant Micronizer is reducing titanium dioxide to under 1 micron at feed rate of 2250 lbs. per hr. For another firm, a 24 in. model grinds 50% DDT to 3.5 average microns at a solid feed rate of 1200-1400 lbs. per hr. A pharmaceutical house uses an 8 in. model to produce procaine-penicillin fines in the 5 to 20 micron range. Iron oxide pigment is being reduced by a 30 in. Micronizer to 2 to 3 average microns.

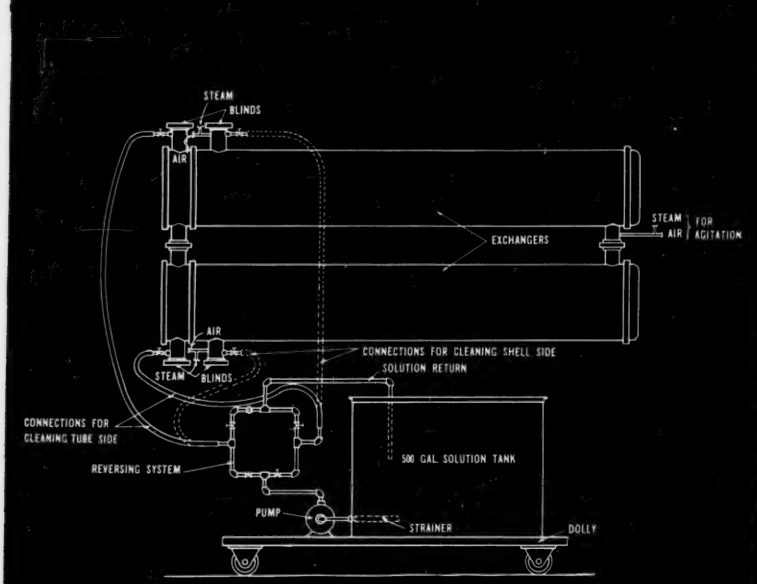
Sturtevant will help you plan a Fluid-Jet system for your ultra-fine grinding and classifying requirements. Write today.

Can Test or Contract Micronizing Help You?

Test micronizing of your own material, or production micronizing on contract basis, are part of Sturtevant service. See for yourself the improvement ultra-fine grinding can contribute to your product. Write for full details. STURTEVANT MILL CO., 100 Clayton St., Boston, Mass.

*REGISTERED TRADEMARK OF STURTEVANT MILL CO.

Another job done better through OAKITE **ECP*** Engineered Cleaning Program



Heat exchanger cleaning made easy —specialized chemicals do the work

An Oakite Engineered Cleaning Program avoids downtime problems by substituting the tireless efficiency of *chemical* cleaning in place of the labored—and haphazard—efforts of manpower.

Take the actual case history of an after cooler with a throughput of phthalic anhydride. Periodically, it loaded up with a pitch-like residue. The whole line would be pulled off-stream for 4 or 5 days while crews sweated around the clock drilling out and rodding each of 500 tubes. Worse yet, drills occasionally went off-center, puncturing tubes and causing *more* downtime for costly repairs.

Instead of muscle-power, the Oakite ECP called for week-end circulation of a mixture of Oakite 24 and Oakite 8, followed by three hours of pressurized water rinse. Result: 500 tubes as slick as rifle barrels—and not so much as a scratch on any of them.

*A comprehensive year-round, plant-wide cleaning program, the Oakite ECP is always specifically tailored to the individual process plant by the Oakite man and the plant engineer. It details methods, materials and schedules for each cleaning chore you face. And it works, because it's built from the engineer's knowledge of equipment and problems and the Oakite man's list of 170 specialized materials, his background in chemical cleaning and his personal supervision.

Write for Bulletin F-10822. Oakite Products, Inc., 18F Rector Street, New York 6, N. Y.

OAKITE. over 50 Est. 1909 SCIENCE years' leadership in industrial cleaning

LITERATURE . . .

Control Valves.....8-page booklet discusses problems facing control valve users and covers shutoff, maintenance, body construction and price comparison.
188A Conoflow Corp.

Diaphragms.....Bulletin lists approximately 1200 standard sizes of rolling diaphragms in bore-sizes from 0.31 to 12.17 inches for strokes from 0.020 to 14.98 inches.
188B Bellofram Corp.

Expansion Joints.....Catalog 56 contains complete & comprehensive engineering data for Expansion Joints from 3″ to 50′ diam., pressures to 3600 psi, temp. to 1600F.
65 *Ballea Brothers

Fittings & Flanges.....are now available for Yoloy piping systems. A comprehensive range of types & sizes for your application. Details are found in Bul. TF-512.
92 *Babcock & Wilcox Company

Flow Tube.....Data sheet describes flow tube designed for use where viscosity of metered fluid is too high to obtain satisfactory accuracy with Venturi Tube or Orifice Plate.
188C B-I-F Industries

Glass Pipe.....Kimax tempered glass pipe never affects your products. Available with complete fittings & accessories for every piping requirement. Catalog.
165 *Kimble Glass Co., Sub. of Owens-Ill.

Heat Exchanger Tube.....Trufin type S/T tube is available in a wide range of alloys & sizes. Trufin type S/T Duplex is also available for use as an outer tube. Inform.
167-168 *Wolverine Tube, Div. of Calumet

Pipe.....Bondstrand plastic pipe is made of tension-wound glass filaments impregnated with resin. Complete information is available in bulletin on physical & design data.
149 *Amercoat Corp.

Plug Valves.....are non-lubricated & non-sticking. Hamer plug valves give maximum service with minimum maintenance. New and complete Hamer valve Catalog 60 is offered.
192 *Well Equipment Mfg. Corp.

Plug Valves, Non-Lubricated.....give a tight seal that can be adjusted on the line when wear develops. Excels in handling of solid bearing liquids or gases. Spec. sheet.
145 *W-K-M Div., AFC Industries

Tubes.....Condenser and heat exchanger tubes are available in over 50 metals and alloys along with Duplex tubes in various materials. Further information is offered.
81 *Bridgeport Brass Co.

Valves.....for the control of hot, cold, erosive, corrosive or viscous fluids. Designed to accept all standard actuators. General Catalog 1500-E is available.
31 *The Annin Company

Valves.....Eccentric-Action, Non-Lubricated valves mean no more leakage-losses and no more greasing or oiling. Details are contained in Control Bulletin 150.
143 *DeZurik Corp.

Valves.....Three-Way Diverting valves divert contaminated fluids to bypass, discharge or recirculating lines. Information on these valves & their application is offered.
12-13 *Minneapolis-Honeywell

* From advertisement, this issue

MI CABLE HELPS TAME REFRACTORY METALS

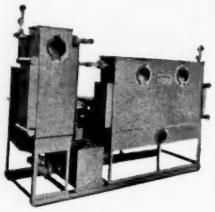
Mineral Insulated Cable is non-breathing. With conductors insulated with magnesium-oxide and encased in a copper sheath—MI is gas- and liquid-tight. This is why Mineral Insulated Cable functions perfectly under the most adverse conditions of heat and atmospheres, where other wiring systems fail. ☐ These features of MI are why Universal-Cyclops Steel Corp. installed Mineral Insulated Cable in its unique new INFAB (INert-FABrication) room. Here, refractory metals like molybdenum and tungsten are hot-worked into sheet and bar at 2000-4500°F, in an argon atmosphere. MI's inherent characteristics were just what Universal-Cyclops needed for reliable power and control circuits. ☐ Whether you're thinking of an INFAB room or more conventional type of wiring that is economical and permanent—specify Mineral Insulated Cable. For details, ask for Catalog S-2. General Cable Corporation, 730 Third Avenue, New York 17, New York

GCC
GENERAL CABLE CORPORATION

frost-free cooling as cold as -90 F

Consulting firms are more and more taking advantage of Kathabar engineers' specialized knowledge about frost-free cooling at sub-freezing dry bulbs and dew points. This knowledge has been accumulated in many successful applications—such as candy cooling, photo film chilling, beer fermentation, ammonium nitrate processing, environmental testing, bakery dipping and icing, and radiant panel cooling.

In all cases, Kathabar equipment eliminates freeze-ups, fluctuating efficiency, defrosting shutdowns, duplicate sets of coils. Take advantage of Kathabar's fund of specialized knowledge . . .



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SURFACE COMBUSTION, *2380* Dorr St., Toledo 1, Ohio

a division of Midland-Ross Corporation MR

Send facts on frost-free cooling for the following application: .....

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name & title .....

address .....

street .....

city .....*zone* .....*state* .....

LITERATURE . . .

Valves.....Gate, Glove and Check valves with hard faced seats feature interchangeable parts. Complete line of pressures, sizes & types. Literature.
94 *Henry Vogt Machine Co.

Valves, Safety-Relief.....Complete information is provided in Catalog FE-118, covering both selection & sizing of Farris process Safety Relief Valves.
180 Farris Engineering Corp.

Process Equipment

Activated Sludge Process.....A new 4-page brochure, Bulletin No. 7320 describes four recent equipment and flowsheet developments for the activated sludge process.
190A *Dorr-Oliver, Inc.

Centrifugals.....The new S-11 centrifugal does the work of three units to reduce installation cost, power cost & floor space. Further information is available.
27 *Baker, Perkins Inc.

Centrifugals.....Reineveld centrifugals may be opened & thoroughly cleaned, inspected and closed in a half hour. Solids remain undisturbed after separation. Bulletin 356.
B206 *Heyl & Patterson, Inc.

Conditioner.....Verticone conditioner with jet spray coats or impregnates particles, granules or powders without degradation. Information is available.
127 *Johnson-March Corp.

Continuous Centrifugal Separation..... built in seven sizes—each with twenty-five variations in design to custom fit the job. Specific information available.
2 *Bird Machine Co.

Continuous Dewatering Presses....Catalog "A" contains complete information that can help you with your pressing, drying and cooling problems.
T206 *Davenport Machine & Foundry

Cryogenic Plants.....range from a simple oxygen, nitrogen, argon liquefying unit to on-site erection of large tonnage production plants. Distribution equipment also available.
172 *Independent Engrg. Co.

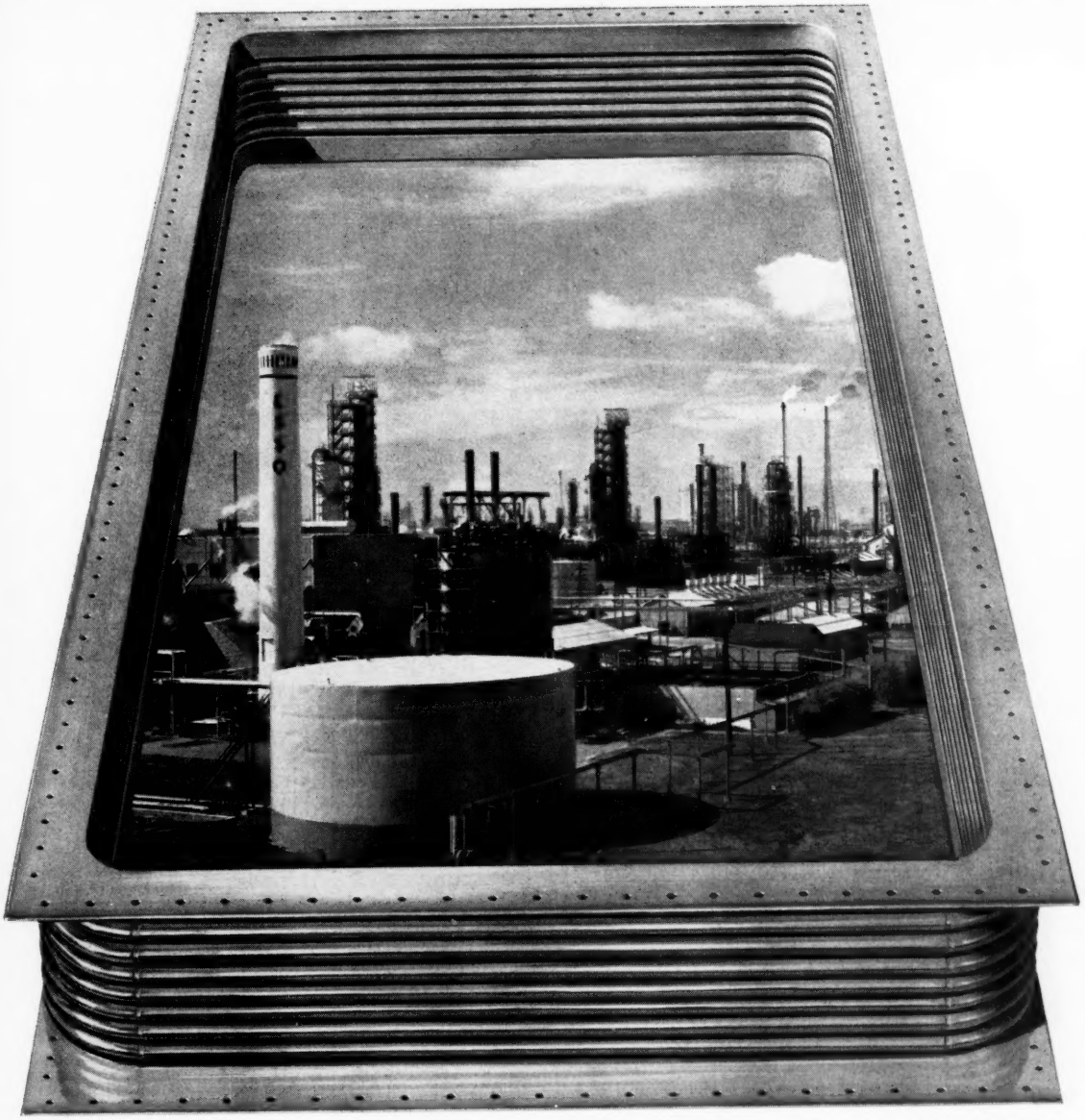
Dryers, Desiccant.....are designed to dry air and gases under pressure (ranging from 1000 to 6000 psig) to dew points of —160F. Full details in Bulletins D-108 & D-109.
129 *The C. M. Kemp Mfg. Co.

Dust Collector.....4-page folder explains versatile cloth filter bag dust control equipment, its manufacture, operation and range of use and application.
190B Pangborn Corp.

Dust Collectors.....Self-contained air pollution control equipment developed for the control of industrial dusts are described in Bulletin 230 which is available.
190C *John Wood Company

Filter, Glass-Bag.....for the toughest industrial applications such as: cement kilns, reverberatory furnaces, calciners, converters, etc. Detailed information.
166 *Dracco Div. of Fuller Co.

* From advertisement, this issue



Giant refineries like Esso Baton Rouge use Sola-Flex *rectangular expansion joints.*

Solar's experience with rectangular expansion joints can help solve your difficult ducting problems

FORTY OF AMERICA'S FIFTY largest businesses—steel, power, petroleum, petrochemicals and others—use *Sola-Flex*® expansion joints to help solve difficult ducting problems and extremes of thermal growth.

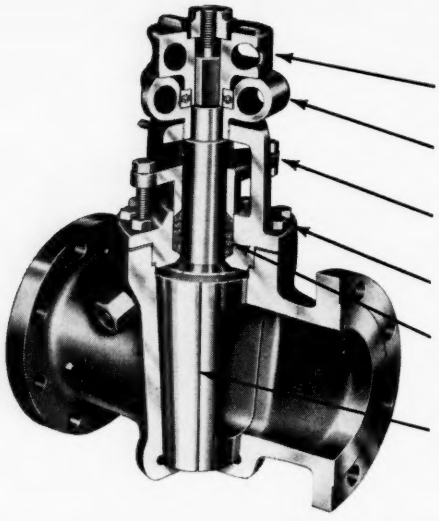
Solar is the most experienced manufacturer of rectangular expansion joints in the world. Two types of rectangular expansion joints are available: U-span with radius corners and V-span with camera-type corners. Sizes range up to 26 ft by 20 ft. Made from all types of stainless steel, Solar rectangular expansion joints withstand both axial and lateral movements and temperatures up to 1000°F. Pressure ranges from vacuum to 15 psig.

Hot or cold, large or small, high pressure or low—no matter what your particular ducting need, Solar can deliver the right expansion joint for any job. Forty-eight *Sola-Flex* expansion joint distributors are located throughout the nation and overseas. They can assure prompt service and advice for users everywhere.

For more information about *Sola-Flex* expansion joints, write Dept. J-174, Solar, San Diego 12, California.

SOLAR

A Subsidiary of International Harvester Company



NON-STICKING . . . POSITIVE SHUT-OFF!

built-in features of

Hamer PLUG VALVES

Hamer non-lubricated, non-sticking plug valve with gland packed steam seal. Standard opening. Sizes 1" through 12" in ASA 150 lbs. and 300 lbs. series. Available in carbon steel and other metals to meet special corrosive and temperature conditions.

You don't have to depend on brute force or lubricant-lift to open or close a Hamer Valve. A special plug adjusting nut, acting as a screwjack, lifts the plug from its seat to assure easy opening and closing. This same nut adjusts the plug in its seat and secures it there for perfect shut-off. A vertical groove in the plug provides a pressure-balancing feature which further facilitates operation of the valve.

Being non-lubricated, there is no danger of product contamination . . . no lubrication expense. The gland packed stem allows packing to be changed under pressure while valve is on stream. Bar operated plug opens or closes with a quarter turn. Larger sizes are available with wheel operators.

Available in sizes, metals, pressures and temperatures to meet a wide range of services in refineries, chemical, petrochemical and other process industries. Ask your WECO, Chiksan or Hamer Valve specialist about the advantages of using Hamer Valves in your plant.

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HV-6-61
Division of CHIKSAN COMPANY
a subsidiary of FMC CORPORATION

WECO UNIONS · CHIKSAN SWIVEL JOINTS · HAMER LINE BLIND VALVES · HAMER PLUG VALVES · WECO AIR-O-UNION · WECO COMPOUNDS · WECO SNATCH BLOCKS

VISIT US AT THE CHEM. SHOW BOOTHS 888, 890, 892 (3RD FLOOR)

LITERATURE . . .

Impact Mill.....dispersions are complete & uniform within the closest tolerances in both batch & continuous processing of dry materials and aqueous suspensions.
163 *Entoleter Inc.

Micronizers.....grind and classify in one operation in a single chamber. Provide fines in range from ½ to 44 microns. Eight models available featuring no attrition heat.
R187 *Sturtevant Mill Co.

Mixers.....Capacities, dimensions and power requirements of continuous mixers are charted for 14 sizes in double shaft and single shaft models in catalog No. 150.
192A Falls Industries, Inc.

Mixers.....Lightnin mixers cut downtime in three places at once. They offer shaft seal assemblies and come all assembled in one package, aligned & ready to install.
210 *Mixing Equipment Co.

Mixers.....in a wide variety of types for every application to increase profit margins and decrease production costs. Three Roller mills, grinding mills, etc. available.
186 *Chas. Ross & Son

Molecular Vacuum Still.....for distilling material with a high molecular weight and contaminated by color, odor or other impurities. Information on request.
184 *Consolidated Vacuum Corp.

Mulling.....Simpson Mix-Muller is designed specifically to put you in control of mixed properties. The Handbook on Mulling is available on request.
91 *National Engineering Co.

Precipitator.....6-page folder desribes sludge-blanket clarifier whose agitator arms are driven by water jets at the tips, shows design and gives operating graphs.
192B Permutit Div.

Process Equipment.....for any process requirement. A new brochure, "From Arc to Atom" has been prepared giving details and is available on request.
131 *A. O. Smith Corp.

RDC Column.....combines many advantages such as high volumetric efficiency, high throughput capacity, elimination of interstage settling, etc. Bul. T-1159.
151 *General American Transp. Corp.

Solids Processor.....adds vacuum drying to liquid-solids blending. Systems completely packaged. In standardized models with charge capacities from 1 to 50 cu. ft.
46-47a *Patterson-Kelley

Vibratory Screens.....Data sheet B-10 gives specifications, dimensions, weights, product features and description of horizontal vibratory screen of balanced-mass design.
192C Comco Corp.

Pumps, Fans & Compressors

Acid Pumps.....in 1" to 8" discharge sizes with 10 to 3000 GPM capacities, heads to 200' and higher. Pumping parts are available in a variety of alloys and plastic.
209 *A. R. Wilfley & Sons

* From advertisement, this issue

LITERATURE . . .

Blowers.....Dynamic blowers can be furnished with protective coatings to resist corrosion & special seals to prevent leakage. Information is offered.
55 *Hoffman Industries, Inc.

Blowers.....feature simple, rugged precision construction with long-lasting lip type seals & non-lubricated compression chamber. Detailed specifications are offered.
L187 *Sutorbilt Corp.

Blowers & Pumps.....Bulletin RAS-261 presents line of displacement blowers and gas pumps, outlines advantages and gives data on performance and operating characteristics.
193A Roots-Connersville

Centrifugal Pumps.....Bulletin 105C illustrates and describes complete line of single-stage, double suction, horizontal split case pumps with capacity range to 6000 gpm.
193B Aurora Pump Div.

Centrifugal Pumps.....Bulletin 301 contains performance curves and technical data on pump designed to handle most corrosive solutions from $AlCl_3$ to $ZnSO_4$.
193C Industrial Filter & Pump

Compressor....."Compressor Evaluation Guide" points out the six key areas of judgment required for compressor evaluation and details them in full.
Cover *Worthington Corporation

Compressors.....Gas engine driven compressors of 1,700 to 3,400 bhp described in 56-page bulletin 225 that gives performance features plus construction details.
193D Clark Bros. Co.

Compressors....."Dry Cylinder" compressors protect your product by complete separation of cylinder and crankcase. Information in Bulletins VE-100 & VE-102.
194 *Corken's Inc.

Metering Pump.....Data sheet describes pump available in four ranges (0-2, 0-5, 0-10 or 0-20 milliliters per minute) and lists features and operating principles.
193E Beckman Instruments Inc.

Pressure Blowers.....Type CB pressure blowers for a wide variety of applications. Capacities to 37,500 cfm & pressure to 74" w.g. Details in Bulletin FI-310.
41 *Buffalo Forge Company

Proportioning Pumps.....12-page bulletin 861 includes capacity and selection tables and a detailed description of the hypocycloidal gears arrangement operation.
193F Jaeco Pump Co.

Pump.....Series 100 pump features accurate metering with smooth control plus double capacity or two-liquid metering. Further information is available.
179 *Wallace & Tiernan, Inc.

Pumps.....for hard-to-handle liquids in the chemical industry. Pumps range from 25 to 2500 hp., pressures to 50,000 psi. Additional information is available.
164 *Aldrich Pump Company

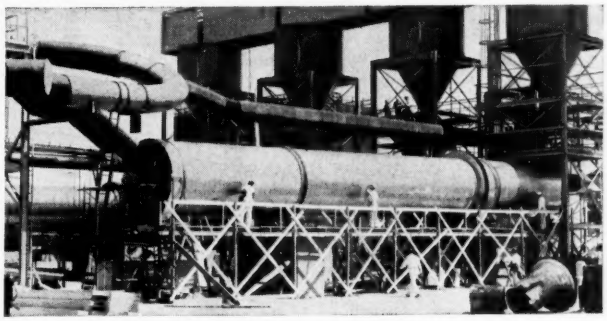
Pumps.....Electri-Cand pumps are built without packing, stuffing box or seals. The unit is completely fluid tight. Safely handles a wide variety of fluids. Details.
137 *Allis-Chalmers

* From advertisement, this issue

STANDARD HERSEY DRYERS

JOB-ENGINEERED CALCINERS

for U.S. BORAX & CHEMICAL CORPORATION



For Chemical, Mining & Allied Industries...
DRYERS
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COOLERS
NODULIZERS
and other
CHEMICAL PROCESSING EQUIPMENT

Two Standard-Hersey rotary calciners are now in operation at U.S. Borax's new refinery at Boron, Calif. These large, modern calciners, one stainless steel-clad, were **job-engineered** and built by Standard Steel.

If you have a processing problem, why don't you, too, call upon Standard's 57 years of rotary processing experience?

STANDARD STEEL CORPORATION
General Offices & Plant, 5005 Boyle Avenue, Los Angeles 58, California
Midwest Offices & Plant **LEADER IRON WORKS** *Decatur 10, Illinois*
(Division of Standard Steel Corporation)
ROTARY DRYERS • KILNS • COOLERS • ASPHALT PLANTS

THIS SELF-CONTAINED FLUID COOLING SYSTEM

...gives most accurate temperature control

Applied in cooling industrial machines or processes to temperatures approaching the ambient wet-bulb, the NIAGARA *Aero*® HEAT EXCHANGER is independent of any more than a nominal water supply or disposal. The coolant system is a closed one, free from dirt and maintenance troubles.

Heat is removed from your process *at the rate of input,* giving you precisely the temperature you require and assuring the quality of your product. Heat may be added to prevent freezing in winter or for better control in a warm-up period. Liquids or gases are cooled with equal effectiveness.

Heat is rejected outdoors. Only the little water evaporated on the cooling coils in the air stream, or discharged to prevent hardness build-up, is consumed.

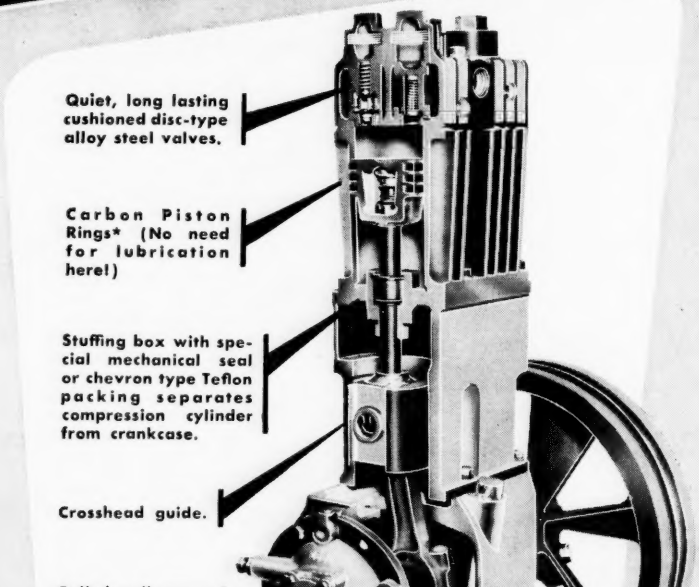
Niagara sectional construction saves you much installation and upkeep expense, gives full access to all interior parts and piping. Your equipment always gives you full capacity and "new plant" efficiency.

Write for Niagara Bulletin No. 132 for complete information

NIAGARA BLOWER COMPANY
Dept. CE-11, 405 Lexington Ave., New York 17, N.Y.
District Engineers in Principal Cities of U. S. and Canada

NO OIL CONTAMINATION WITH CORKEN "DRY CYLINDER" COMPRESSORS

Your product is protected by complete separation of cylinder and crankcase!


Quiet, long lasting cushioned disc-type alloy steel valves.
Carbon Piston Rings* (No need for lubrication here!)
Stuffing box with special mechanical seal or chevron type Teflon packing separates compression cylinder from crankcase.
Crosshead guide.
Built-in oil pump for pressure lubricating all bearings in crankcase area.

*Other frictionless materials available.

WRITE FOR BULLETINS VE-100 AND VE-102

Available as single-or two-stage machines—

(Single Stage Duplex)	(Two Stage)
Displacement 4—37 CFM	2—23 CFM

Max. Discharge Press. 265 PSIG—500 PSIG Intermittent

CORKEN'S INCORPORATED

PHONE CE 5-5517
P. O. BOX 1062
OKLAHOMA CITY, OKLA.

LITERATURE . . .

Services & Miscellaneous

Buyer-Seller Alliance.....Booklet E-9 in Professional Advancement series analyzes relationship between engineer engaged in specifying and engineer engaged in selling.
194A Western Supply Co.

Eye Protection.....A booklet, "How to Install an Eye Protection Program" for guidance & assistance in establishing a sound, workable eye protection program.
194B *Fendall Company

Facts Booklet.....A complete treatment of human relations in engineering is given in Booklet E-6, "Facts-of-Life" which has been prepared for engineers & is available on request.
L204 *Western Supply Co.

Fire Fighting Products.....To step up your department's life-saving power, equip with FOAM systems, nozzles and FOAM liquid. Complete details are available.
28 *Rockwood Sprinkler Co.

Fire Guards.....Booklet describes fire check for fuel-fired combustion systems that automatically shuts off the flow of combustible mixtures when flashback occurs.
194C C. M. Kemp Mfg. Co.

High Vacuum Equipment.....23-page catalog describes high vacuum systems, instruments and valves and provides detailed descriptions and technical specifications.
194D F. J. Cooke Inc.

Hydrants.....B-50-B hydrants are built for exceptional service. Available in types & sizes for practically every installation. Bulletin 5710 is available for details.
35 *Darling Valve & Mfg. Co.

Industrial River Sites.....A booklet is available on request showing industrial river sites available in Alabama. Maps & other information are included.
194E *Alabama Power Company

Maintenance Cleaning....Sixteen fact-filled pages in a new booklet spell out the latest procedures for chemical cleaning of chemical soils. Bulletin No. F-10822.
188 *Oakite Products, Inc.

Marking System.....New Mark-Trol eliminates 95% of the mess & maintenance of round chart recorder inking systems. Literature is offered for further details.
67 *The Esterbrook Pen Co.

Noise Control.....16-page booklet shows how to set up a noise control program to achieve safe and efficient working conditions and discusses necessary equipment.
194F H. H. Scott, Inc.

Skylights.....Wasco Twin Dome skylights are completely sealed, insulated and shatterproof. Inner & outer domes available in any combination. Information.
16-17b *American Cyanamid Co.

Water Distillation.....Portfolio contains data sheets describing three distillers (flash, vapor compression and vapor compression-forced recirculation).
194G Badger Mfg. Co.

* From advertisement, this issue

BECHTEL

San Francisco

Bechtel Corporation offers immediate employment opportunities to chemical engineers experienced in process design of major petrochemical, refinery, or similar processing units.

Liberal transportation and relocation allowances for you and your family. Please send resume of experience, including present and required salary, to W. A. Anderson, Technical Recruiting.

Bechtel Corporation
220 Montgomery Street
San Francisco, Calif.

REFINERY CHEMICAL ENGINEERS SOUTH AMERICA

Desired for opportunities in modern refineries of an affiliate of STANDARD OIL COMPANY (NEW JERSEY) operating in South America. Candidates must be graduate Chemical Engineers with 5 to 10 years refinery experience and a thorough knowledge of process design and process control. Opportunities exist for assignments to Economics, Lubricants and Oil Movement, and Distillation Sections of Process Engineering Group as well as the Laboratory Group and Operating and Maintenance Groups. Salary including bonus from $15,000 to $17,000 annually depending upon experience. Liberal employee benefits including annual home vacations with travel allowance. Interviews will be arranged for qualified candidates. All replies confidential. Send complete resumé of work experience and personal data to:

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New York 19, New York

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POSITION VACANT

Small midwestern chemical plant dealing with pigments and dry colors, which has just secured additional capital for major expansion, looking for a young, aggressive business man, preferably with some chemistry background, as Assistant to President. P-7822, Chemical Engineering.

PROFESSIONAL SERVICES

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UNITED INTERNATIONAL RESEARCH, INC.
Consultants in Chemical Research for over 20 years
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CHEMICAL ENGINEERS

(BS-MS-PhDs)

for

Linde

. . . First in cryogenics and foremost producer of industrial gases and cryogenic equipment . . . immediate professional opportunities at its Engineering Laboratory in Tonawanda, for men with up to 5 years' engineering experience. These are permanent positions; strong interest and training in thermodynamics, heat transfer, fluid mechanics, strength of materials and thermodynamic processes, desirable.

CRYOGENIC PRODUCTS

Exciting new area requiring top technical personnel to invent and develop unique applications for cryogenic fluids and equipment in programs ranging from food preservation to space study.

BASIC ENGINEERING

Research and development in the above specified areas.

CREATIVE PLANT DESIGN

Process design, plant assembly and instrumentation, plant start-up and evaluation.

DESIGN AND DEVELOPMENT

Application, handling and distribution of acetylene and cryogenic fluids.

Please send resume to Mr. J. E. McMahon, Head of Employment, Dept. 3723. All inquiries will receive prompt and confidential attention.

LINDE COMPANY UNION CARBIDE

UNION CARBIDE CORPORATION

P. O. Box 44, Tonawanda, N. Y. (A suburb of Buffalo)

An equal opportunity employer

Growth Company engaged in the production of thermoplastic polymers has several career opportunities for men with some processing backgrounds. New England location.

ENGINEERING MANAGER

This man will assume complete responsibility for direction of group engaged in plant process engineering. Position requires a "take charge" individual.

PROCESS ENGINEERS

Expansion of facilities requires the addition of several Mechanical or Chemical Engineers. These are excellent opportunities for men with 1 to 5 years experience in industry.

Please write P-7776, Chemical Engineering
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

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MOLECULAR SIEVE PRODUCTS DEPARTMENT

. . . Recipient of the 1961 Kirkpatrick Award for outstanding chemical engineering achievement . . . . offers exceptional professional opportunities to

CHEMICAL ENGINEERS (BS-MS)

Experience in chemical process technology desirable.

- **PROCESS DEVELOPMENT**
- **CREATIVE PROCESS DESIGN**
- **PRODUCTION**
- **FIELD SALES**

Please send resume to Mr. J. E. Schmidt, Personnel Department 3738. All inquiries will receive prompt and confidential attention.

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Equipment Searchlight

CE's Searchlight spots the big bargains in used, resale and rental equipment.

Check this issue's listings—most complete in the field—for items you need now.

PUBLIC AUCTION SALE

THURSDAY, DEC. 14, 1961, 10:30 AM

at CROWLEY DIVISION

1 Central Avenue, West Orange, New Jersey

TABLET and PREFORM PRESSES: 52 Stokes, Kux, Colton 4 ton to 150 ton, single punch and rotary, single and dual pressure types, including: Stokes R4, R, T, F, DDS2, etc. Kux 82, 74, 65, 64, 54, 52. 800 Ton Baldwin-Southwark Hydraulic Hobbing Press.

EXTRUSION PRESSES: 3—225 Ton Baldwin Southwark and Watson Stillman horizontal hydraulic, vacuum head.

BLENDING AND MIXING EQUIPMENT: Cowles dissolvers, double arm sigma blade mixers, ribbon blenders, Simpson muller mixers, Gruendler mixer, Paterson conical blender, mixing tanks, tumbling barrels.

CRUSHING AND PULVERIZING EQUIPMENT: Lancaster crusher, Stainless steel Fitzmills, Stokes granulators, Stokes and Abbe Steel lined ball mills up to 5' x 6', Stokes tornado mill, Hammermills, Gruendler crusher, Stokes jacketed vacuum ball mill, vibrating screens, sifters.

FURNACES, KILNS, DRYERS, OVENS: Bufflovac twin drum stainless steel rotary dryer, 36 cubic feet Steiner Ives ovens, Allied 64 ft. car type continuous gas furnace; American Gas 20' x 3', 6' x 2', and 9' x 15" horizontal rotary kilns, melting furnaces, gas blowers, heat treating furnaces, rotary indexing furnaces 24 ft. diameter, all sizes ovens.

LABORATORY EQUIPMENT: Complete inspection and testing machines, Baldwin Southwark 300,000 lb. tensile and compression tester, lab presses, balancers, scales, moisture testers, vibrators, electronic testers, etc. Complete Tool, Die, Mold Machine Shop. Maintenance Dept. Air Compressors. Material Handling Equipment. Tools & Dies for Powder Metallurgy Parts.

Send for descriptive catalog:

INDUSTRIAL PLANTS CORP.

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CIRCLE Z ON READER SERVICE CARD

HOW to LOCATE EQUIPMENT

without cost or obligation

This service is aimed at helping you to locate Surplus New or Used equipment, if you do not find your present requirements advertised in this section.

Send us the specifications of the equipment wanted and you will receive an immediate reply with full details.

EQUIPMENT FINDERS BUREAU
SS-6663, Chemical Engineering
Class. Adv. Div., P. O. Box 12, N. Y. 36, N. Y.

CIRCLE A ON READER SERVICE CARD

SPECIAL BARGAIN OPPORTUNITIES

3000 KW, 3600 RPM, 80% P.F., 3/60/13,800 V., UNUSED Allis Chalmers non-condensing automatic extraction steam turbine generator unit, 425 PSIG, 700-750°FTT, 170 PSIG automatic extraction, 60 PSIG back pressure.

1500 KW, 3600 RPM, 80% P.F., 3/60/2300 V., General Electric non-condensing steam turbine generator unit, 375 PSIG, 650-700°FTT, 85-125 PSIG back pressure.

NEW, UNUSED Babcock & Wilcox coal pulverizer, Type E-56, equipped with American Blower Corporation air fan, 15,000 CFM capacity with motor drive. Complete coal pulverizer installation with blower air fans, attached and unattached structural parts, capacity 14,600# per hr.

This excellent equipment is offered at a fraction of replacement cost.

Utilities Machinery Corporation
912 National City E. Sixth Bldg.
Cleveland 14, Ohio Telephone CH-1-0210

CIRCLE B ON READER SERVICE CARD

LIQUID OXYGEN PLANT

4.75 to 5 tons 99.5% Lox in 24 hours. Diesel driven. Produces about 2 lbs Lox per lb of fuel. Priced at a fraction of new.

FREELAND PRODUCTS COMPANY
3233 Conti Street New Orleans 19, Louisiana

CIRCLE C ON READER SERVICE CARD

2—New 5000 Gallon Pressure Vessels

Mfgd. by Babcock & Wilcox. ASME rated. 1750# oper. press.; 3572# press. tested. 650 deg. F max. temp.; Weight 80,500# Blt. 1952. Size 23' L x 53" I.D. With piping, valves, fittings, etc.

Pressure pumps—all sizes and kinds available.

EVEREADY—Box 1780—Bridgeport, Conn.
Ed McCallum ED. 4-9471

CIRCLE D ON READER SERVICE CARD

LOOK HERE!
COMPARE THESE PRICES

4—KARBATE PUMPS

Model 4-CA-9-½. 6" x 4" each with 40 HP motor. Cap 1500 GPM @ 37' head. Used only 6 months. Condition like new.

Cost Price....$1760.00 OUR PRICE..$950.00

Wire or phone collect—GA 1-1380

MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE E ON READER SERVICE CARD

to our friends now attending the Chem Show we extend a welcome

LIQUIDATIONS

CLEVELAND, OHIO

1—Raymond #73612 Super High Side 6-Roll Mill, with whizzer, cyclone, piping and motors.
1—Raymond #5047 High Side 4-Roll Mill, with whizzer, cyclone and piping
1—#1 Raymond Impact Mill, with whizzer, cyclone and piping.
1—Kilby Nickel Single Effect Force Feed Evaporator, 1200 sq. ft.
2—Oliver 5'3" x 4' Nickel Clad Rotary Vacuum Filters.
2—Pfaudler 300 and 200 gal. Glass Lined Jkt. Agt. Reactors.
1—Sperry 30" C.I. Filter Press, 27 chambers.
1—Buflovak 32" x 90" Dble Drum Dryer.
4—Feinc 8' x 12' Rotary Vacuum Steel Filters, string discharge.
2—6'6" dia. x 60' Rotary Dryers.
1—5½' x 4½' x 50' Rotary Dryer.
7—Dorr 80' and 40' thickeners.
6—Nash H10, H8, H6, H5, & L5 Vacuum Pumps.
2—Tyler Hummer 3' x 10' Double Deck Screens.
2—Fuller Kinyon Pumps H6.
1—Link-Belt 24" x 90' Belt Conveyor.
5—Nickel Centrif. Pumps, 2", 3".

CENTRIFUGES

2—Bird 18" x 28" Solid Bowl Continuous 304 S.S.
1—Bird 40" x 60" Solid Bowl Continuous 316 S.S. UNUSED.
5—Sharples C-20 and C-27 Super-D-Hydrators 316 S.S.
1—DeLaval AC-VO Continuous S.S. 20 HP.
3—Sharples PY14, PN14 Super-D-Canters 316 S.S.
2—Sharples #16, 304 S.S., 3 HP motor.
1—Tolhurst 40" 347 S.S. imperforate basket 15 HP. UNUSED.
1—Bird 40" Suspended imperforate basket 40/10 HP.

REACTORS—EVAPS—CONDS—COLUMNS

4—Glascote 500 gal. glass lined, Jacketed Reactors.
1—Pfaudler 125 gal. 304 S.S. Jkt. Agit. Reactor, 150# int., 125# jacket.
3—Pfaudler 100 & 50 gal. glass lined, Jkt. Agit. Reactors.
1—8650 sq. ft. NICKEL double effect forced Circulation Evaporator, UNUSED.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—3000 sq. ft. O. G. Kelly 309 S.S. forced feed Evaporator, UNUSED.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—300 sq. ft. Swenson 347 S.S. Single Effect Evaporator.
1—250 sq. ft. Buflovak 304 S.S. Single Effect Evaporator.
10—Stainless Heat Exchangers; 910, 536, 370, 250, 131, 70 sq. ft.
5—Pfaudler 26 sq. ft. glass lined Condensers.
1—4'6" x 46' 316 S.S. Clad Column, 250 PSI.
8—3' x 20', 30" x 19' 347 S.S. Packed Columns.
1—24" x 35' 304 S.S. Bubble Cap Column.

FILTERS

2—Niagara 370 sq. ft. Vert. 304 S.S.
1—Niagara 110 sq. ft. Vert. 316 S.S.
1—Niagara 92 sq. ft. Vert. Jkt. 316 S.S.
1—#10 Sweetland, 36 leaves 3" centers.
1—#5 Sweetland 304 S.S., 120 sq. ft.
1—Oliver 6' dia. Horizontal 316 S.S.
1—Oliver 4' dia. Monel Horizontal.
1—U. S. 200 sq. ft. 304 S.S. Auto-Jet.
1—Hercules 400 sq. ft. 304 S.S. Pressure.
3—Oliver Precoat 5' x 6', 5' x 10', 8' x 10'.
1—Oliver 5'3" x 8' Steel Rotary Vac Housing.
1—Feinc 3' x 1' 316 S.S. Rotary Vac.

DRYERS

1—Buflovak Vacuum Shelf, 17-60" x 80" shelves.
2—Buflovak 42" x 120", atmospheric double drum complete.
1—Buflovak 32" x 90" Atmos. Twin Drum.
2—Devine 4' x 9' single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum.
6—Louisville Rotary Steam Tube, 6' x 30', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary.
3—Rotary Dryers 6' x 50', 7' x 80', 8' x 80'.
1—Link Belt 6'4" x 24" Roto Louvre 316 S.S.
1—Link Belt 3'10" x 16' Roto Louvre.
1—4' dia. 304 S.S. Spray Dryer.
1—Wyssmont, 304 S.S. 6'2" dia.

MIXERS—MILLS

1—Sturtevant 75 cu. ft. 304 S.S. Rotary Batch Blender 20 HP.
1—Abbe 110 gal. 304 S.S. Jacketed Agitated Vacuum Dispersall Mixer.
2—Baker Perkins 150 and 100 gal. Jacketed double arm Sigma blades.
1—Baker Perkins 50 gal. jacketed.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
1—Steel jacketed Powder Mixer, 225 cu. ft.
1—50 cu. ft. Powder Mixer, 304 S.S.
1—Day 120 cu. ft. Jumbo Powder Mixer, 25 HP motor.
1—45" dia. Lancaster Mixer 7½ HP.
3—Hardinge 6' x 36", 5' x 22" and 3' x 24", steel lined conical Ball Mills.
2—Mikro Pulverizers, 2TH and 1SI.

TANKS

25—500 to 3500 gal. Vertical 304 S.S. Tanks opened and closed, some agitated.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2000 gal. Horizontal 304 S.S. Tank 5' x 12'.
1—2500 gal. Vertical 304 S.S. Tank 8' x 7'.
1—10,000 gal. Rubber Lined Tank 10' x 17'6".
1—5500 gal. 316 S.S. Clad Pressure Tank 250 PSI.
2—3000 gal. Aluminum Tanks, 7' x 11'.
5—25,000 gal. Aluminum Storage Tanks.

Partial List of Values—Send for Complete Circular

BRILL EQUIPMENT COMPANY

35-61 JABEZ ST., NEWARK 5, N. J. Tel: MArket 3-7420—N. Y. Tel: RE 2-0820
TEXAS OFFICE: 4101 San Jacinto St., Houston 4, Texas—Tel: JAckson 6-1351

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- ALCOHOL
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- SELLITE
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- SULPHURIC ACID CONCENTRATING

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CIRCLE G ON READER SERVICE CARD

NIAGARA FALLS, N. Y. and EVERETT, MASS.

EQUIPMENT OFFERINGS

Sharples C-27 SUPER-D-HYDRATOR 316 Stainless Type BM-123C-65C, 40 HP motor

Baker Perkins 300 gallon Stainless Steel Size 18DIM Sigma Blade MIXER, 30 HP motor

Nash L3 Stainless VACUUM PUMPS 140 CFM (3)

11,500 gal. Stainless TANKS Agitated (2)

48"x41' Vulcan Stainless BUBBLECAP COLUMN 40 trays, 70 caps/tray, 100 PSI design

72"x30' Budd Stainless BUBBLECAP COLUMN 21 trays, 38 caps/tray

Pfaudler 500 gal. ELL GLASS LINED REACTOR, agitated, 75 PSI jacket, 25 PSI internal

Pfaudler 300 gal. EL GLASS LINED REACTOR, agitated, 90 PSI jacket, 25 PSI internal

4500 gal. 347 Stainless COiL PANS, 6'x20' with 25 turns of 2" Stainless coil (2)

5'3"x3' Oliver Precoat Rotary VACUUM FILTER, Vaporite, 316 Stainless

Link Belt 604-24 Stainless ROTO-LOUVRE DRYER

1860 sq.ft. Stainless REBOILER 271-1"x12 tubes

8'x60'x⅝" Allis-Chalmers ROTARY KILN

60"x84" Single deck Rotex #421 SCREEN

Swenson EVAPORATOR 435 sq. ft. Stainless single effect condenser, vapor separator

1000 gal. Dopp Ni-resist jktd., agit. REACTOR

1000 gal. Steel REACTOR, jacketed & agitated, 125 PSI internal, 25 PSI jacket

LaBour PUMP 316 STAINLESS 125 GPM, 211' head, Model DZ23—1½"x2", 15 HP (3)

500 ft. Glass lined jacketed PIPE 2", 3" and 4"

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Chemical Plants & Equipment

306 sq. ft. STAINLESS EXCHANGER, ¾" tubes

36"x20' COLUMN 316 Stainless Packed, 100 PSI

4'x40'x⅜" ROTARY DRYER, NEW welded shell

LaBour PUMP STAINLESS STEEL 750 GPM @ 80' Type Q, 50W, 30 HP 3/60/220/440 V. (4)

4000 gal. Vertical Type 347 STAINLESS STEEL TANK 8'x12' with dished heads

6'x36" Hardinge CONICAL BALL MILL, 75 HP

Buflovak 6' jacketed vacuum CRYSTALLIZER

1000 sq ft. STAINLESS EXCHANGER, ¾" tubes

10'x150' ROTARY KILN complete

78"x18' STAINLESS 316 BUBBLECAP COLUMN 14 trays, 180 caps/tray, 100 PSI

12"x18' STAINLESS PACKED COLUMN, 100 PSI

8'x150' ROTARY KILNS complete (2)

8'x90' ROTARY DRYER complete

10,500 gal. 316 Stainless TANK 10'x23' Vertical

3,500 gal. 304 Stainless TANKS 8'x9' Vertical

2,300 sq. ft. Stainless EXCHANGER, 1" tubes

16"x10'7" Pfaudler GLASS LINED SCRUBBER COLUMN 25 PSI and full vacuum

77 sq. ft. Stainless FINTUBE EXCHANGERS (8)

Swenson Stainless Jkt. CRYSTALLIZERS 24"x20'

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CIRCLE H ON READER SERVICE CARD

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HERE ARE SOME OUTSTANDING SELECTIONS

Vacuum Shelf Dryers by Devine and Buffalo up to 86" x 78"	2 Sturtevant Micronizers 30" with Syntron Vibrators
Stainless Steel Suspended Centrifugals from 30" to 60"	Bird Continuous Centrifugal Filter in Stainless, 18" x 28"
Sharples C 27 Super-D-Hydrator in Type 316 Stainless; 40 HP	Welded Steel 6500 Gal. Reactor Lined with Brick; ASME Pressure
S. S. Lined Rotary Dryer 50" x 20', Counter Current with Accessories	Rotex and Roball Sifters-Screens Single & Multiple Deck to 120"
Baker Perkins Double Arm Jacketed Mixers from 2 Gal. to 300 Gal.	Oliver Pre-Coat Rotary Vacuum Filters; Acid Resistant to 8' x 10'
A. O. Smith Pressure Tanks, Stainless Lined 10' x 18' with agitators	Shriver and Sperry Ni-Resist and Stainless Filter Presses to 30"
Porcelain Lined and Buhrstone Pebble Mills up to 8' x 8'	Mikro Pulverizers, all types in size from Bantam to No. 4's
Raymond Automatic Pulverizers, Imp Mills and Screen Mills etc.	Buffalo Stainless Thermo-Compression Evaporator, complete
Nickel Clad Reactor 7' x 11'6"; Jacketed-Agitated; Manhole Top	Stainless Steel Reactors from 60 Gal. to 2000 Gal. Jktd. Agtd.
Aluminum Bubble Cap Column; 60 Plate, 27½" x 36' complete with accessories	Link Belt Roto Louvre Dryer Model No. 502-20 complete
Sargent & Wilbur Ammonia Disassociator Type A; 10,000 Cu. Ft. per hr. Hydrogen	Lancaster Stainless Lined Rotary Reactor, 50" x 17'4"; Jacketed
Banbury Mixers, Model #00, No. 9 and No. 11.	Louisville MONEL Rotary Steam Tube Dryer, 54" x 35'. Stokes Rotary DD2 23 Station Tablet Press

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CIRCLE J ON READER SERVICE CARD

STERILIZER, American 30" x 42" x 7' w/quick opening door each end—150 PSI Jacket

OVERPACK CARTONER, R. A. Jones—Automatic for 6 pack carton 4⅝" x 3½" x 5½"

ROTARY DRYERS, 24" x 22', 36" x 24'4", 5' x 45' (almost new), 5' x 50', 7' x 58"

FEEDERS—SYNTRON, F 22 s/s w/8" trough, F 45 s/s w/24" x 72" trough, F 33 20" x 46" pan (New) Jeffrey #4 w/36" x 36" pan

SCREENS, 5' x 20', 5' x 12', 42" x 10' double—Rotex 40" x 120", Patterson 28" x 28" s/s, Roball 40" x 84", Rotex 20" x 37"

LAWLER COMPANY
Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE K ON READER SERVICE CARD

BEST VALUES

Evaporators: Four St.St. Buflovak dbl. eff. 608-708-845-1125 sq. ft. each. Long tubes.
Evaporators: Three St.St. sgl. eff. 94-150-216 sq. ft. each. Long tubes.
Double Ribbon Blenders: (2) Day 119 cu. ft. St.St. 10 H.P. drives. Like new.
Votator: Girdler three 4" x 46" stainless cylinders and rotors, ammonia chilling system.
Vacuum Dryer: Stokes 2' x 6' Rotary, jacketed, St.St. With drive, condenser, receiver.
Dryers: Double Drum, 42 x 90; 32 x 90 Buflovak.
Dryers: Double Drum, 42 x 120; 36 x 84 American.
Dryer: Raymond Flash Dryer and Cooler with cyclones, furnace, ducts, etc. 20,000#/hr. Never Used.
Twin Shell Blenders: P.K. 5 cu. ft. St.St.; P.K. 30 cu. ft. steel, with intensifier.
Centrifuges: Tolhurst 40" and 26" Suspended, perf.
Centrifuges: Tolhurst 48" St.St. T316, Underslung perf.
Tanks: (2) 2300-1500 gal., vertical St.St.
Tanks: (2) 3000-1500-900 gal., vertical St.St. for vacuum with coils.
Kettles: (2) 600 gal. agitated St.St.; with 15 P.S.I. steel jacket.
Glass Lined Kettle: 750 gal. Pfaudler. 50 PSI shell, 90 PSI jacket; agitator.
Mix Muller: Simpson, Size #2, 1000 lb. St.St. 15 H.P. drive.
Vacuum Batch Dryer, Bartlett & Snow, 8' dia. x 2'5" dp. Jacketed. All steel.

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34—VACUUM PUMPS

Stokes Model 212 C each complete with 5 HP motors. Capacity 115 CFM. Excellent condition. Special price on quantity purchases.

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LIQUIDATIONS—

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ORANGE, TEXAS
OMAHA, NEBRASKA

AUTOCLAVES
KETTLES — REACTORS

1—2000 gal. Glascote blue G/L reactor
50—1400 gal. Pfaudler blue G/L jkt. Kettles, Agit., baffles.
3—1350 gal. T347 SS kettles, open top
13—1250 gal. Pfaudler blue G/L jkt. reactors, Agit.
1—1000 gal., T316 SS jacketed reactor, ASME, UNUSED.
1—1000 gal. Dopp cast iron kettle, 125# jacket, 15# int., Agit.
4—800 gal. horiz. T316 ELC SS clad, ASME, Vacuum—Unused.
1—750 gal. Graver T304 SS jkt. fermenter, ASME Agit.
2—600 gal. T304 SS reactors, jkt., Agit.
1—500 gal. Pfaudler glassed reactor.
50—600 gal. Pfaudler Stainless jacketed kettles, open.
2—500 gal. T304 SS reactors, jacketed, ASME, Vacuum—Unused.
6—465 gal. T304L SS reactors, jacketed, 150# int., 175# jkt.
1—300 gal. T304 SS jacketed reactor, vac. ASME—UNUSED.
1—300 gal. Pfaudler blue G/L reactor, Agit., jkt., ASME.
2—200 gal. T304 SS jkt. reactors, ASME, UNUSED.
1—175 gal. T304 SS jkt. reactor.

JUST PURCHASED

1—Buflovak 2' x 7'-10" T304 SS jacketed rot. vacuum dryer, ASME.
1—60 sq. ft. Heresite lined vac. shelf dryer.
1—Merco #CX-16 centrifugal T316 SS.
2—Pfaudler 500 gal. "R" series jkt. glassed reactors, Agit.
6—Pfaudler Dbl.-jktd. glassed thimble condensers: 62, 47, 14 sq. ft.
1—Pfaudler 100 gal. "P" series glassed jkt. reactor, Agit.
1—Artisan 1200 gal. T304 SS jktd. reactor, vacuum, Agit.
1—Process Eng. 450 gal. T316 SS jkt. reactor, Agit.
2—1600 gal. vert. T316 SS tanks, coils.
1—Tolhurst 40" susp. cent., T316 SS.
2—A.T.&M. 36" susp. cent., rubber-covered perf. basket.
1—5800 gal. horiz. Alum. tank, 8'-6" x 12'-3", dished heads, UNUSED.
1—80 gal. T347 SS autoclave, 350 psi int., 100 psi jkt., Agit.
1—165 gal. Struthers-Wells horiz. Titanium Autoclave, ASME 100 psi, (3)-vert. agit., elec. hecters.
1—90 sq. ft. Whitlock T316 SS condenser, ASME 1000 psi shell & tubes.
2—Feinc 3' dia. T316 SS horiz. filters.
1—12,000 gal. horiz. steel ammonia tank, 250 psi, 8' x 30' dished.
1—Fitz. #K-8 Stainless comminutor.
1—Symons 2' shorthead crusher.

STAINLESS STEEL TANKS
(T304 UNLESS NOTED)

3—20,000 gal., 14' x 15', T316LC, cone bottom, 3/8".
2—13,000 gal. 11'10" x 15'7".
1—12,000 gal 9'-6" x 22', T304 SS, horiz., dished—UNUSED.
4—10,000 gal., 12' x 12', T316 SS, vert., 15 HP turbine Agit.
1—10,000 gal., 12' x 12', T316 SS vert., turbine Agit., jacketed.
4—5800 gal., 10' x 10', T316 SS, Agit.
2—5700 gal. horiz., 6'-4" x 24', UNUSED.
2—4500 gal. vert., 8' x 12', UNUSED.
5—3650 gal. 10' x 7', vert., open.
1—3350 gal., 8'x8'6", agit., 50 psi.
1—3300 gal. 6' x 14'-6", vert.
1—3250 gal., 6' x 15', T316.
7—3000 gal., 8' x 8', T316 SS, Vert.
2—3000 gal. 8' x 8' vert.—UNUSED.
1—2800 gal., 5' x 18', dished.
2—2600 gal., 7' x 8', T316 dished.
1—2250 gal., 8' x 6', T316, coils
5—2100 gal., 8' x 5'6", dished.
1—2100 gal., 6' x 9', T316, cone.
12—1750 gal., hoppers, 4'-5" x 7'-4" x 9'-2".
4—1350 gal., 4' x 14', T347, dished, ASME 60 psi coils.
5—1350 gal., 7' x 4'-6", T321.
1—1300 gal., 6' x 6', 3/8", dished.
3—1100 gal., 4' x 11', T347, 60 psi.
3—1000 gal., 4'-6" x 8'-6", dished.
3—850 gal., 4' x 9', 3/8", dished.
1—800 gal., 5'x5'6", 1/4", dished.
3—750 gal., 5' x 5', 3/16", dished.
6—685 gal., 3' x 13', T316, coils.
3—300 gal., 4' x 3', T347, 60 psi.

DRYERS — KILNS

2—Buflovak 42" x 120" double drum dryers, ASME 160# WP.
1—American 42" x 120" dbl. drum.
1—Buflovak 42" x 90" dbl. drum.
2—American 36" x 84" dbl. drum.
1—Buflovak 32" x 52" dbl. drum.
1—American 36" x 84" double drum dryer, ASME, VACUUM.
1—Buflovak 5' x 12', single drum dryer, Vacuum, UNUSED.
1—Buflovak 6" x 8" dbl. drum.
5—Stokes 195 sq. ft. vac. shelf dryers.
1—Buflovak 98 sq. ft. vac. shelf.
1—60 sq. ft. Heresite-lined vacuum shelf dryer.
1—Buflovak 2' x 7'-10" T304 SS rot. vac. dryer, ASME, jktd., Agit.
1—Nerco-Niro stainless spray dryer.
1—10' x 11' x 175' Vulcan kiln.
6—10' x 100' rotary dryers, 5/8" welded shell, complete.
2—B. & Snow 8'-6" x 70' rotary dryers, 5/8" welded shell, late model.
1—7'6" x 62" rotary kiln, 1/2".
1—6' x 150' rotary kiln, 5/8" welded.
1—Louisville 5' x 30' steam-tube.
2—Louisville 4'-6" x 25' rotary steam-tube dryers, welded.
1—Bartlett & Snow 3' x 15' rotary dryer, Everdur metal shell.
1—3' x 23' rotary, 1/4" welded.
3—Bartlett & Snow 14" x 18'5", stainless rot. calciners, complete.

STAINLESS PIPE & VALVES

50,000'—T304 SS pipe, sch. 10 & 40, 1" to 6".
20,000'—T304 SS vapor pipe, to 24".
10,000—T304 & T316 SS flanged valves, to 8".

EVAP. — STILLS
COLUMNS — EXCHANGERS
— BOILERS

1—6500 sq. ft. Swenson T316 SS 3-body, 2-stage vert. long-tube evap.
7—4050 sq. ft. calandria type evap., copper tubes, cast iron shell.
1—1250 sq. ft. Mojonnier dbl.-effect Stainless Sanitary evaporator.
3—Buflovak double-effect stainless evap. vert. long-tube, 840, 710, 588 sq. ft.
1—630 sq. ft. Struthers-Wells T316 SS Calandria evap.
1—320 sq. ft. steel reboiler.
1—250 sq. ft. Buflovak T304 SS, single effect recompression evap.
1—118 sq. ft. Stokes T316 SS still.
1—36" dia. x 6 plate T316 SS column.
2—Vulcan T316 SS 10 plate bubble cap columns: 110", 60" dia.
6—30" x 19' T347 SS packed columns.
8—24" x 16' Duriron packed columns.
1—24" x 33' Duriron & SS column.
1—1960 sq. ft. T316 SS exchanger remov. bundle, ASME 75# WP.
1—1450 sq. ft. T316 SS condenser.
5—1400 sq. ft. T316 SS gas converters.
1—900 sq. ft. T304 SS exchanger.
3—800 sq. ft. T316 SS condensers.
1—730 sq. ft. T316 SS exchanger.
6—691 sq. ft. copper dbl. pipe cooler.
1—510 sq. ft. T316 SS condenser.
8—400 sq. ft. T304 SS pipe coolers.
12—Amer. Heat Reclaiming T316L SS spiral exchangers: 162, 73 sq. ft.
15—75 sq. ft. nickel pipe coolers.
30—T316 SS heat exchangers & condensers: 425, 400, 290, 277, 200, 165, 150, 142, 105, 73, 54 sq. ft.
50—Duriron exchangers & condensers.
3—Waste-heat boilers, 250 psi.
5—Comb. Eng. 435 HP water-tube boilers, 300 psi.

STAINLESS PUMPS

Aldrich T316 SS 3-cylinder piston pumps: 3 1/8" x 5", 2 3/8" x 3", 1 1/2" x 2".
Worthington Worthite Cent. Pumps; 4" x 3", 3" x 2", 2" x 1 1/2", 1 1/2" x 1", w/motors.
LaBour 2" 316 SS self-priming cent. pumps w/motors.
Aurora 1 1/2" SS sump pumps

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Gas Converter, G. E. G5, 4000 CFH, 400°F., 125# (2)
Lectrodryer, PITTSBURGH, Size 750, Type BWC, 100# W. P.
Drycolene Producer, G. E., 2000°, 200 cu. ft., Type "G"
Screen Vibrator, J. H. Day, 50" x 116"
Wood Crusher, WILLIAMS, HF, Swinging Hammer Type, 30 HP
Crusher, #2400 AMERICAN, Ring Free 50 HP, 2½-3½ Tons per hour
Hammermill, DIXIE, Swing Knives, requires 25-30 HP
Tablet Machine, #1035 COLSON, 35 station, 1" die
Calandria Pan, vacuum pump, 11'8" diameter x 13' high
Stainless Tank, 42" dia. x 60" high, 10 gage, bottom discharge

TANKS—Vertical & Horizontal 7500-8000 gallons

Pressure Vessels, acid proof bronze, 42" x 72", 125# pressure
Muller/Mixer, BAKER PERKINS, 36" x 84" opening, 100 HP
Mixer, SIMPSON, 36" diameter tub, 5 HP—NEW
Mixer, Style C #2 SIMPSON, 6' diameter
Dust Collectors, Type D AMERICAN, #8 Rotoclone (6)
Dust Collectors, AMERICAN, Rotoclone, 5250 CFM
Extractor, TOLHURST, 48", 7½/40 HP

CRANES:

#83 BYERS, ⅝ yd. 38' boom, diesel, magnet controls, generator, 1947
#25 NORTHWEST, ¾ yd. 35' boom
#79 LORAIN, 1¾ yd. 60' boom, diesel
BROWNING Locomotive, 40 ton, 70' boom, diesel
LORAIN Yard, 20 ton, 40' boom
MC-416 THEW LORAIN Truck, 20 ton, 30' boom
#357 UNIT Mobile 30' boom, ⅜ yd.

ELECTRIC HOISTS—¼ to 5 TON CAP.

Oil Purifiers, HONAN-CRANE—NEW (4)

SCOTCH MARINE TYPE BOILERS:

ECLIPSE Gas or Oil, 145#, 50 HP; New 1958
J & L Vertical High Pressure, 175#, 50 HP
CLEAVER BROOKS Package, Oil, 30# pressure, 30 HP (3)
#22 JOHNSON, Oil, 125# press., 250 HP, New 1953

SEPARATORS:

DINGS Magnetic, 20" x 15" drums—NEW
RAYMOND Mech., Air., 4" dia. feed, 1 dbl. & 1 single Whizzer type
#C1824 STEARNS Magnetic, portable, 12" x 20" drums, 2 HP

HYDRAULIC PUMPS—*ALL SIZES*
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2—Nickel Shell & Tube Heat Exchangers 4325 sq ft. All nickel contact

1—Williams 5 Roller Hi Side Super Titan Mill. 125 HP. New 1957

1—Raymond Model 5048 Hi-Side 4 Roller Mill. Complete with Whizzer and TEFC motors

1—Sharples C-27 type 316 SS Super Dehydrator. 40 HP Mtr. Diversion valve

1—Niagara 500 sq ft vertical leaf Filter. SS lvs. auto sluicing

2—16' Whizzer Separators. 1—Raymond Double Whizzer, 1—Sturtevant

3—Eimco 8' x 12' rotary cont. Vacuum Filters. All steel closed drums. Variable speed drives

1—Baker-Perkins 300 gal work cap. SS Sigma Mixer. Unidor type

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CIRCLE Q ON READER SERVICE CARD

LOCOMOTIVE—RR CARS & CRANES

9 Gen. Elec. 20, 25, 45, 65, 70, 80, 100, 125 Ton
25-Ton Industrial Brownhoist 60' Boom Crane
200—50 Ton Box 300—70 Ton Gondola Cars
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1—Pfaudler 750 gal. glass lined jacketed reactor.
1—Glascote 750 gal. glass lined jacketed vacuum receiver.
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72—Alloy Fabricators 400 gal. SS jacketed reactors complete with agitators and drives.
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1—Struthers Wells 300 gal. Hastelloy "B" jacketed kettle.
1—Blaw Knox 300 gal. SS vacuum reactor.
1—Van Alst 300 gal. SS jacketed kettle.
6—Blaw Knox SS vacuum receivers, 100 and 200 gals.
1—125 gal. SS jacketed autoclave with impeller type agitator and drive, 125 psi jacket, 75 psi internal.
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1—Buflovak steel jacketed rotary dryer, 3' x 15'.
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1—J. H. Day 5 gal. double arm sigma blade jacketed mixer, SS.
1—Gemco SS double cone jacketed blender, 69 cu. ft.
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Robinson type 304 SS horizontal blender, 125 cu. ft.
3—Sprout Waldron 30 cu. ft. jacketed double ribbon blenders, steel.
1—Stokes SS granulating mixer, Model 21-J.
1—Sturtevant #7 dustite rotary batch blender—NEW.

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4—Patterson SS condensers, 200 and 300 sq. ft.
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3—Mikro #3TH SS pulverizers.
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One of our basic problems seems to stem from our relationships with *others* — our reactions to the drives of other people and their reactions to ours, because, like it or not, we *are* affected by other people, and they are affected by us.

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This limited space, of course, does not permit a full look at this most complex of subjects, but a more complete treatment of human relations in engineering is found in our Booklet E-6, "Facts-of-Life," available free upon request. Write for your copy to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA.—and remember, *our* success and happiness stem partially from the heat exchangers in *your* future.

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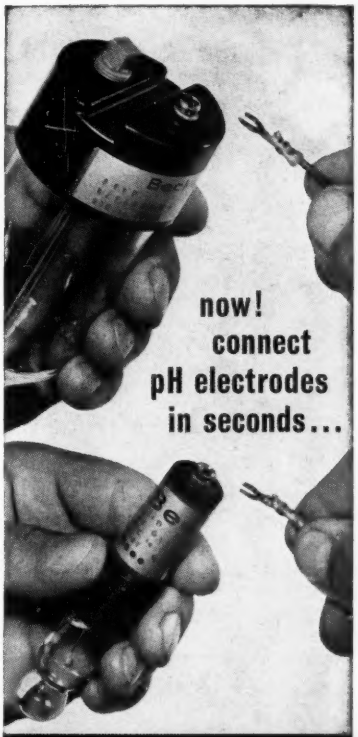

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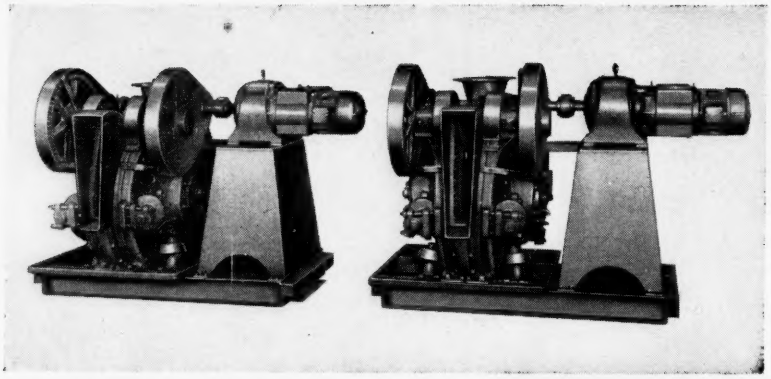

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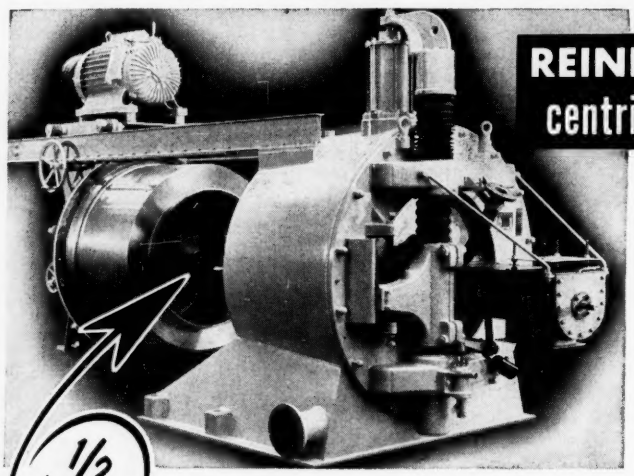

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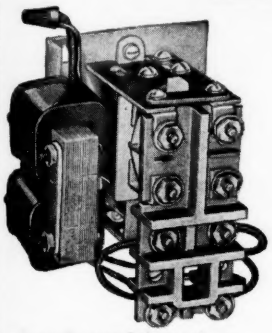

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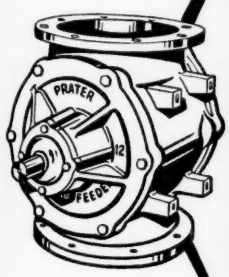

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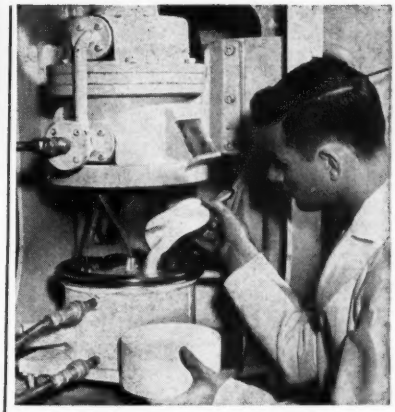

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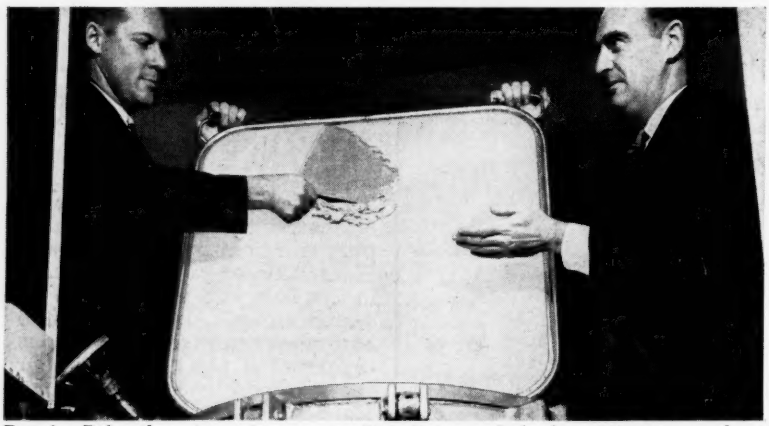
DICALITE®

TECHNICAL REPORT

DICALITE DEPARTMENT • GREAT LAKES CARBON CORPORATION • 612 SO. FLOWER ST., LOS ANGELES 17, CALIFORNIA

Dow Lowers Filtration Costs With Solka-Floc®/Dicalite® Precoating



Douglas Babcook, assistant brewmaster, Dow Brewery, Ltd., demonstrates ease of removal of Solka-Floc/Dicalite precoat to J. H. McAuliffe, Brown Company representative.

Four hours longer filter runs, polishing an additional 700 barrels of beer *with the same amount of filteraids* – that is what Solka-Floc/Dicalite precoating is doing for Dow Brewery, Ltd., in Montreal, Canada.

Dow's final polish filtration is through a Niagara filter followed by a tubular paper insert trap filter. This final polishing system was developed after extensive tests to achieve the most efficient and economical method of final polish filtration consistent with the highest standards of clarity.

A Solka-Floc skin coat pre-coat technique combined with standard grades of Dicalite was adopted after an extensive test period. Through the use of Solka-Floc, diatomaceous earth "bleed-through" was prevented and longer cycles were obtained. This enabled Dow to eliminate slower and costlier pad-type trap filters and fully utilize their standard vertical metal screen filters.

Dow's new streamlined system consists of the following: The Niagara filters are pre-coated with 25 pounds of Solka-Floc BW40 (called Alpha Floc in Canada). This is followed by a mixture of 50 pounds of Dicalite Speedplus® and 15 pounds of Dicalite UF.® A combination of Dicalite Speedplus and Dicalite UF is used as body feed.

With this method, filter runs average 14 hours, as against the 10 hour previous average, with 2,450 barrels throughput as compared with 1,750 – yet filteraid consumption has not been increased!

Assistant Brewmaster Douglas Babcook states that additional filters have been ordered because of the success of this method. "With the Solka-Floc/Dicalite combination, we have eliminated powder bleed-through, and have a quality beer filtration with greater economy," he explains. "The combination gives a tough, resilient and even pre-coat. Also, the Solka-Floc fibres are short enough not to foul our proportioning pumps – asbestos was not good in this regard – and Solka-Floc shows no tendency to 'ball up' when being proportioned or pumped."

Further tests now in progress at Dow promise the same type of improvement in primary filtration, and Dow has indicated its intention of expanding the use of this method to all its breweries if the completed tests bear out the early findings.

If you have a precoating problem, or a "difficult" filtration, a Dicalite engineer will be glad to discuss with you the possible advantages of Solka-Floc/Dicalite combinations in your operations.

Dicalite's "Man on the Spot" George Lee

An important member of the group which helped work out Dow's precoating procedures was George Lee, of Lee Benner Chemicals, Ltd., Dicalite's representative for eastern Canada.

George has been identified with the chemical field for nearly 30 years, having received his B.A.Sc. in Chemical Engineering from the University of Toronto in 1932.

A short stint with Glidden was followed by sales work in the chemical division of Canadian Industries Limited. In 1946 he became vice-president of the McArthur Chemical Company, Ltd. Lee became the Dicalite representative when he established his own business in 1955.

Since founding Lee Benner Chemicals, George has specialized in filtration, and has worked closely with many Canadian firms on filtration problems.

J. H. McAuliffe Brown Company

Jack McAuliffe, who pioneered the Solka-Floc application with Dow, has been with Brown Company, makers of Solka-Floc, since 1950.

Starting as Assistant Export Sales Manager, he has been in Domestic Sales since 1955, developing new applications and techniques of use. Appointed Regional Sales Manager for New England and Quebec in 1957, he advanced to his present post in 1959, as Regional Sales Manager for Solka-Floc Sales for New England and Canada, and Regional Sales Manager of the Pulp Division for the eastern United States and Canada.

TECHNICAL LITERATURE

on Dicalite Filteraids is available on request. Write to the Dicalite Dept., 612 So. Flower St., Los Angeles 17, Calif.

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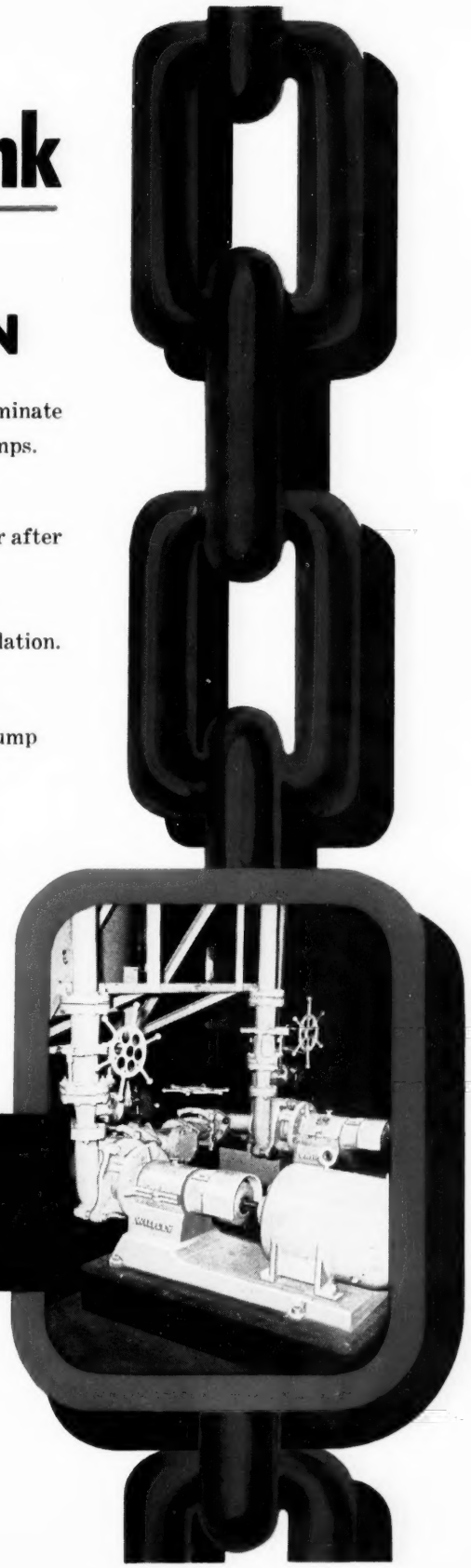

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Our booth is No. 146—opposite the left-side entrance to Main Floor exhibits. We'll be glad to see you.

A. Study of flow patterns.
1. Mass transfer rate in a liquid-liquid column.
2. Heat-transfer problem on analog computer.
3. High-viscosity blending demonstration with spiral impeller.
4. Vessel geometry in a heat-transfer operation.
5. Multiple-stage operation in a gas-liquid column.
6. Study of solid-liquid settling rates.
7. Cutaway of pipeline LIGHTNIN mixer.